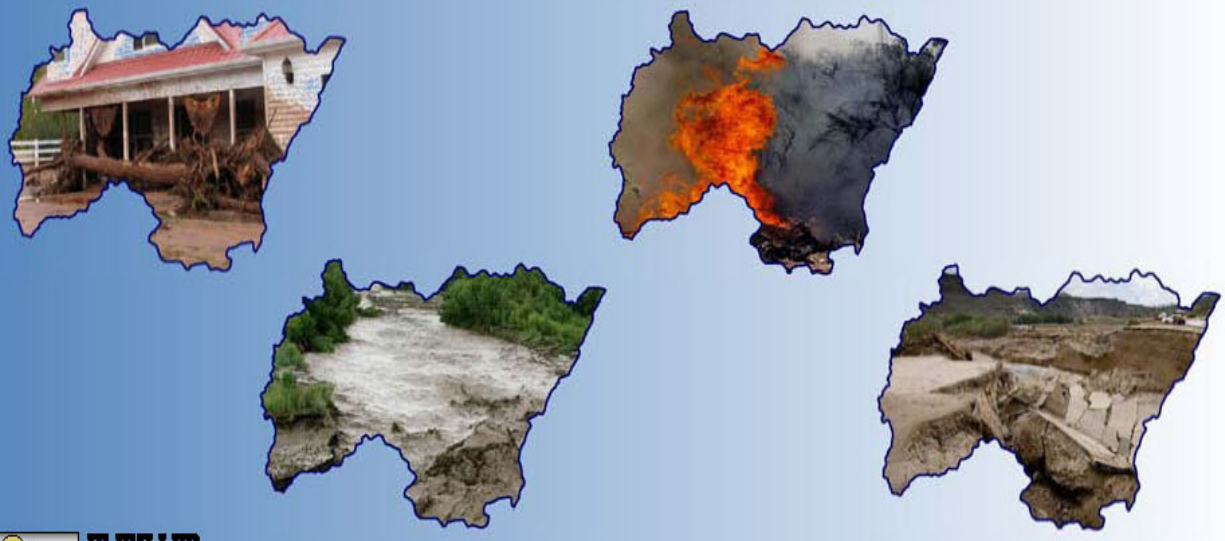
US Army Corps of Engineers

Virgin River and Tributaries

Floodplain Management Strategy



JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.
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March 2008

US Army Corps of Engineers®

VIRGIN RIVER and TRIBUTARIES
Utah, Arizona & Nevada

FLOODPLAIN MANAGEMENT STRATEGY

March 2008

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Contract No. W912PL-06-D-0011

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List of Acronyms/Abbreviations

404 Permitting	-	Refers to permitting conforming to Section 404 of the Clean Water Act
ALERT	-	Automated Local Evaluation in Real Time
ASDSO	-	Association of State Dam Safety Officials
ASFPM	-	Association of State Floodplain Managers
BLM	-	United States Bureau of Land Management
BMP	-	Best Management Practice
CCRFCD	-	Clark County Regional Flood Control District
CFS	-	Cubic feet per second (ft^3/s)
EA	-	Environmental Assessment
EAP	-	Emergency Action Plan
EHZ	-	Erosion Hazard Zone
EIS	-	Environmental Impact Statement
EPA	-	Environmental Protection Agency
ESA	-	Endangered Species Act
EWP	-	Emergency Watershed Protection (An NRCS Program)
FEMA	-	United States Federal Emergency Management Agency
FIRM	-	NFIP Flood Insurance Rate Map
FP	-	Floodplain
FWS	-	Flood Warning System
GIS	-	Geographical Information Systems
JD	-	Jurisdictional Determination/Delineation
JEF	-	JE Fuller Hydrology & Geomorphology, Inc.
NCD	-	Natural Channel Design, Inc.
NCRS	-	Natural Resource Conservation Service
NDOW	-	Nevada Department of Wildlife
NEPA	-	National Environmental Protection Act
NFIP	-	National Flood Insurance Program
NOAA	-	National Oceanic and Atmospheric Administration
NPS	-	National Park Service
NWIS	-	National Water Information System
NWS	-	National Weather Service
PCN	-	Pre-Construction Notification
RWA	-	NRCS Rapid Watershed Assessment
SNWA	-	Southern Nevada Water Authority
SWPPP	-	Storm Water Pollution Prevention Plan
USACE	-	United States Army Corps of Engineers
USDA	-	United States Department of Agriculture
USFS	-	United States Forest Service
USFS	-	United States Forest Service
USFWS	-	United States Fish and Wildlife Service
USGS	-	United States Geological Survey
VR	-	Virgin River
VRFPMS	-	Virgin River Floodplain Management Strategy
VRHCP	-	Virgin River Habitat Conservation and Recovery Program
WCWCD	-	Washington County Water Conservancy District

EXECUTIVE SUMMARY

The Virgin River and Tributaries Floodplain Management Strategy (VRFPMS) is a undertaking by the U.S. Army Corps of Engineers (USACE) to facilitate collaborative, multi-jurisdictional, watershed-based strategies for floodplain management. The Virgin River watershed is approximately 5,900 square miles within six counties among three states (Arizona, Nevada, and Utah). The Virgin River is one of the largest unregulated (undammed) rivers in the western United States. The watershed has a history of flooding with records dating back to settlement by western expansion pioneers. In the 20th century alone, major flooding was recorded along the Virgin River corridor five times. More recently, a regional flood occurred in 2005 which damaged homes in all three states and triggered over $66 million in federal emergency funding. In August 2007, separate flood events on the same day caused damage to multiple homes in two towns.

The development of the VRFPMS comprises a seven-step process with the following sequence: Data/ Information Collection, Flood Hazard/ Risk Identification, Floodplain Management Goals, Mitigation Actions, Floodplain Management Strategy, Implementation Plan, and Communication Plan development.

Data/ Information Collection. Information about floodplain management successes/ needs was collected from stakeholders in both group and individual settings. Previous reports, technical studies, and data pertinent to strategy development were reviewed.

Flood Hazard/ Risk Identification. From stakeholder input and previous studies, flood hazards were identified for the watershed. Unlike humid regions with perennially flowing streams, the Virgin River Watershed is semi-arid with predominantly intermittent or ephemeral streams. Riverine hazards in these areas are typically rapid-rise inundation (flash flooding), erosion hazards, and channel migration. Multiple aspects affecting these hazards were identified including the prevalence of wildfires, channel conveyance loss due to invasive species, urbanization, and sedimentation and debris blockage hazards.

Floodplain Management Goals. Two floodplain management goals were identified. The first goal is to improve both intra- and inter-agency communication between stakeholders in emergency and non-emergency situations. The second goal is to implement measures for floodplain management to minimize flood hazard/ risk exposure.

Mitigation Actions. The next step in the work plan was to identify necessary action items to ensure, to the extent possible, that the floodplain management goals are met. These action items are components of the hazard mitigation toolbox. The primary criteria for selection of mitigation actions were feasibility and cost effectiveness. A total of fourteen Mitigation Action items were selected, as follows:

1. Floodplain Management Handbook
2. Public Information Brochure
3. Contacts Database
4. Flood Response Plan
5. GIS Database
6. Flood Detection Network

7. Post-Fire Hydrologic Assessment
8. Floodplain Delineations
9. Erosion Hazard Delineations
10. Channel Conveyance Conservation
11. Floodplain, Floodway, and Erosion Hazard Zone Regulations/ Ordinances
12. Design Standards, Guidelines, and Publications
13. Streamlined Permitting Process/ Maintenance
14. Floodplain Management Strategy Steering Committee

The following priority actions were identified by stakeholders at the December 13, 2007 meeting in Hurricane, UT: Establish a Watershed Steering Committee, Conduct Post-Fire Hydrologic Assessments, Develop and Conduct Public Information/Outreach, and Implement a Flood Warning System (Flood Response Plan/Flood Detection Network).

Floodplain Management Strategy. The Mitigation Actions were purposefully selected to comprise the toolbox necessary to achieve the floodplain management goals. The Mitigation Actions, or tools, were then organized to formulate a framework for each strategic goal. The tools were categorized as follows:

- ✓ Information Resources.
- ✓ Flood Warning System.
- ✓ Basic Data.
- ✓ Technical Resources.
- ✓ Channel Conveyance.
- ✓ Regulatory Toolbox.

Implementation Plan. The VRFPMS consists of fourteen Mitigation Actions which will require the collaboration, resources, and focus of a myriad of stakeholder agencies and entities. Clearly, a road map by which the VRFPMS will be implemented is necessary to facilitate a successful outcome(s). The purpose of the Implementation Plan is to be that road map. The Implementation Plan consists of the following elements:

- ✓ *What* – Mitigation Actions
- ✓ *Why* – Interest/ Benefit to Floodplain Management Goals
- ✓ *How* – Funding and Assistance Programs/ Resource Materials
- ✓ *When* – Short-, Mid-, Long-term Priorities/ Progress Milestone Identification
- ✓ *Who* – Participating Stakeholders/ Partner Resource Agencies

Communication Plan. One common theme heard from the stakeholders was the need for improved communications between and within jurisdictional agencies and with landowners, citizen groups, and the general public. An effective communication plan will require various components for use as information resources by stakeholders.

- ✓ Floodplain Management Handbook
- ✓ Public Information Brochure
- ✓ Contacts Database
- ✓ Emergency Communication Protocol
- ✓ GIS Database
- ✓ VRFPMS Steering Committee

1.0 INTRODUCTION

1.1 Report Authorization

The Virgin River and Tributaries Floodplain Management Strategy is one component of the Virgin River Watershed Analysis, a multi-jurisdictional study currently underway of the Virgin River watershed in Utah, Arizona, and Nevada. The Virgin River Watershed Analysis is one of five comprehensive studies being conducted by the U.S. Army Corps of Engineers (Corps) that were funded through General Expenses in response to the Fiscal Year 2006 Energy and Water Development Appropriations Act (PL 109-103). That legislation directs the Secretary to conduct "at full federal expense, comprehensive analyses that examine multi-jurisdictional use and management of water resources on a watershed or regional scale."

The Virgin River Watershed Analysis comprises three work products; including a needs analysis, watershed strategy, and floodplain management strategy. In carrying out this watershed analysis, work has been conducted in partnership with local and county governments, state and federal agencies, municipalities, landowners, citizen groups and the public. This collaborative effort will produce a watershed plan that assists stakeholders within the Virgin River watershed in successful management of the river, tributaries, and related resources.

In carrying out this watershed analysis, the Corps is working in partnership with local and county governments, state and federal agencies, municipalities, landowners, citizen groups and the public. This collaborative effort will produce a watershed plan that assists stakeholders within the Virgin River watershed in successful management of the river, tributaries, and related resources.

This project was initiated in the summer of 2006 and is scheduled to be completed during the first quarter of the 2008 calendar year. The Floodplain Management Strategy was prepared under Contract No. W912PL-06-D-0011.

1.2 Project Description

The Virgin River headwaters are located in Washington, Kane and Iron Counties, Utah. The lower watershed includes portions of Mohave County, Arizona and Clark and Lincoln Counties, Nevada. Major tributaries include the East and North Forks of the Virgin River in the upper watershed, Fort Pearce Wash and the Santa Clara River in the central portion of the watershed, and Beaver Dam Wash in the lower watershed. The river outfalls into the Colorado River at Lake Mead in southeastern Nevada. The distance from the headwaters to Lake Mead is approximately 200 miles. The drainage area above Lake Mead is approximately 5,900 square miles. See Figure 1 for a location map showing the limits of the Virgin River watershed and jurisdictions. Figure 2 shows land ownership within the watershed boundaries.

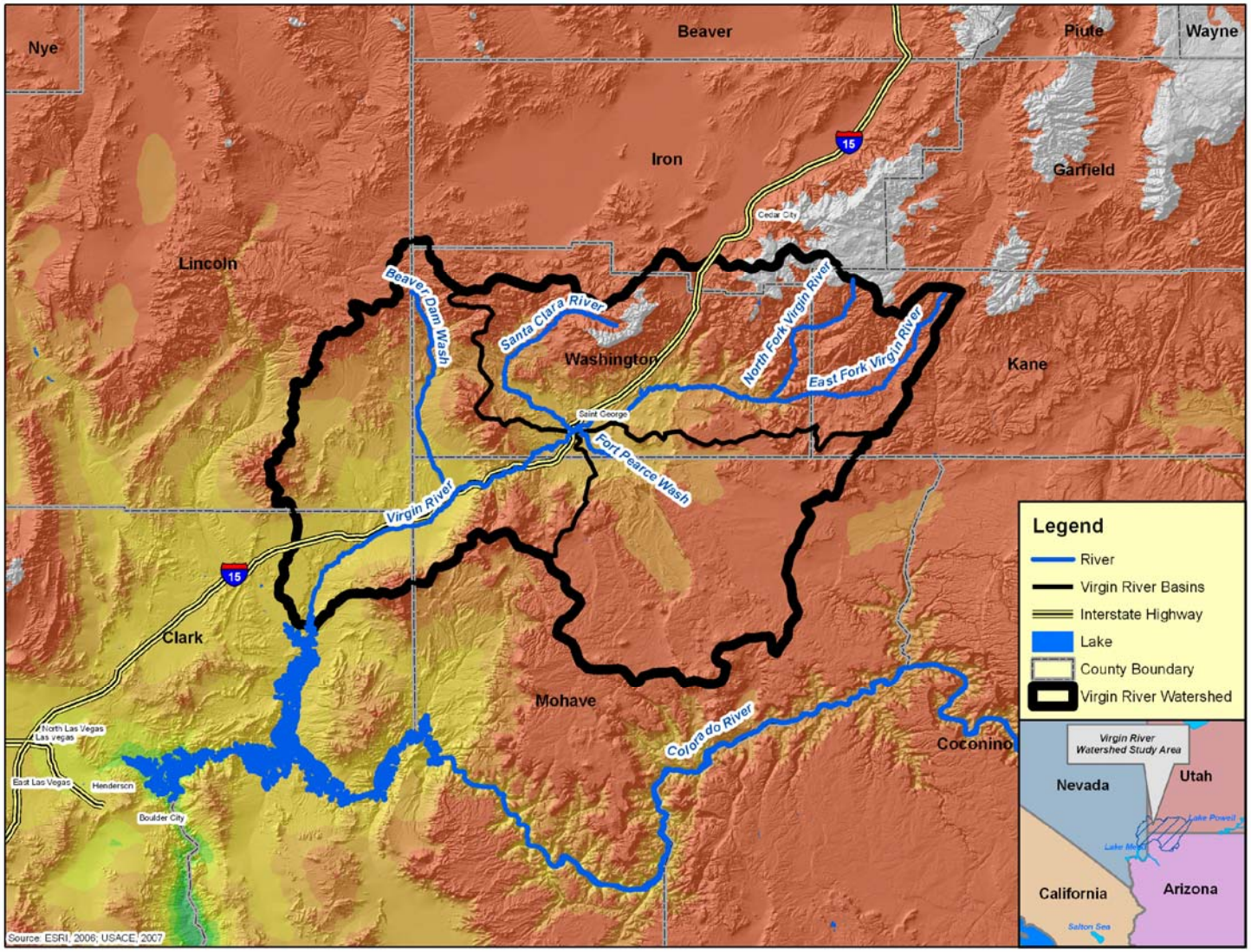


Figure 1 - Location Map

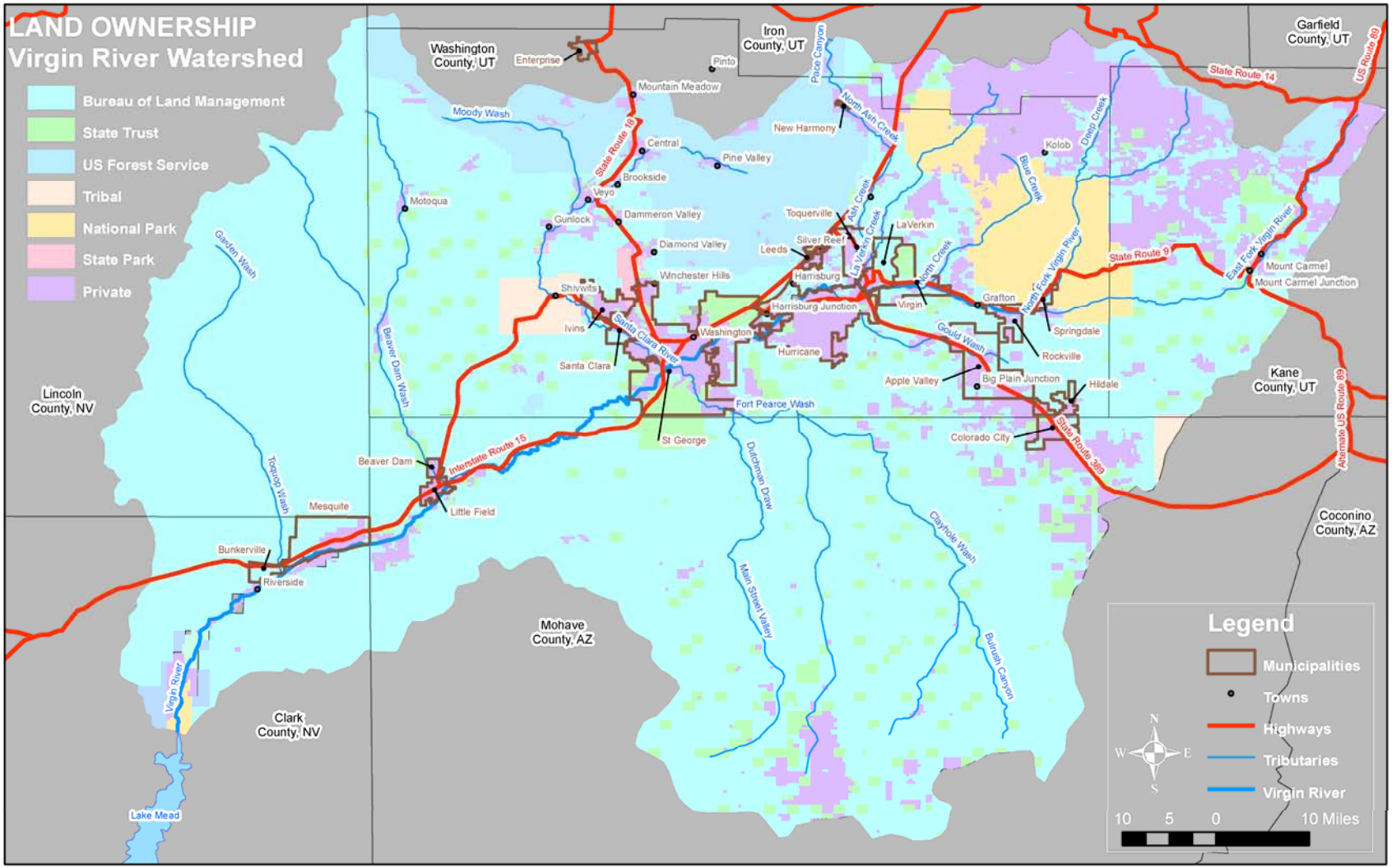


Figure 2 - Land Ownership within Virgin River Watershed

Much of the watershed is in Federal or state ownership. Despite the large percentage of publicly owned lands, private ownership of land occurs in rapidly growing areas such as Washington County, Utah; Clark County, Nevada; and Mohave County, Arizona.

The Virgin River watershed is one of the largest essentially unregulated and free-flowing rivers in the western United States. The watershed is being impacted by rapid development and expanding infrastructure in Washington County, Utah and northeast Clark County, Nevada. Much of the development is occurring in lowland areas adjacent to, and within, floodplains and erosion hazard areas. The development also impacts critically important habitats for protected and sensitive wildlife species.

Watershed-wide issues include floodplain management, land use planning, river function, invasive species, and water supply. Individual agencies and consortiums are considering these issues in varying ways on differing scales, but no watershed-wide plan has been developed. The purpose of the Corps' Virgin River Watershed Analysis is to address these issues comprehensively as a whole. The Virgin River Watershed Analysis is documented in a separate report.

In concert with a watershed management plan, a more comprehensive approach to floodplain management will increase public safety and awareness, reduce flood damages to property, and protect the natural and beneficial functions of the floodplains. The overall goal of the floodplain management strategy will be to guide communities and stakeholders in the implementation of coordinated mitigation activities to achieve these objectives. This report documents the Virgin River and Tributaries Floodplain Management Strategy (VRFPMS) portion of the Virgin River Watershed Analysis.

The VRFPMS is not intended to consist of a resource-intensive set of recommended structural capital improvement projects. Rather, the VRFPMS will be successful upon effectively leveraging available resources to facilitate stakeholder communication for the purpose of implementing strategic mitigation activities beyond the completion of the comprehensive Virgin River Watershed Analysis. Section 2.0 of this report provides an overview of floodplain management and documents the economic impacts of flooding demonstrating the need for a watershed-based effort in the Virgin River watershed.

1.3 Work Plan Overview

The VRFPMS was formulated using a work plan comprising eight steps as shown in the schematic presented in Figure 3. A brief description of each step in the work plan and the desired outcome follows.

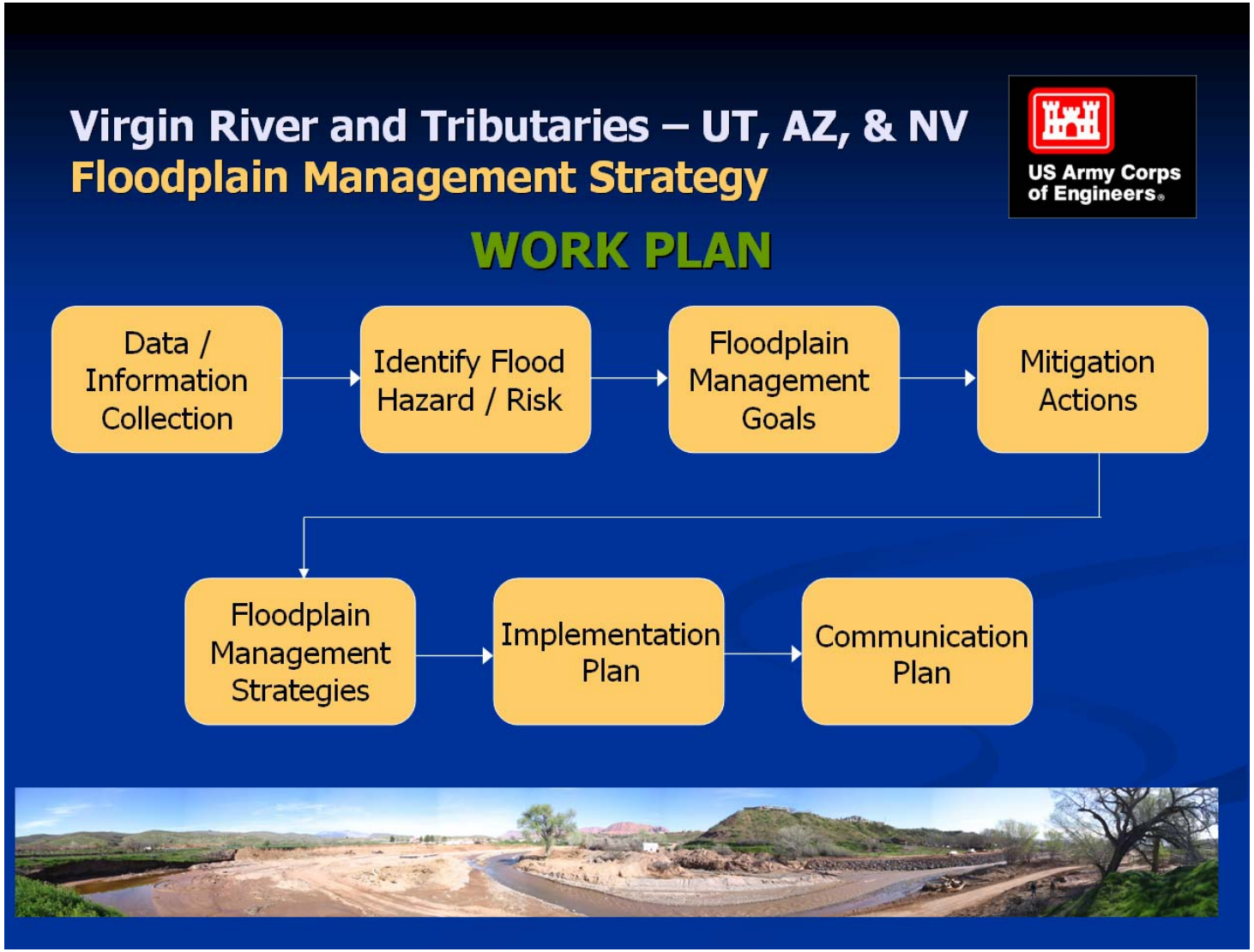


Figure 3 - Virgin River Floodplain Management Strategy Work Plan

Data Collection. The VRFPMS work plan began with a data/ information collection task. The desired outcome was as follows:

- ✓ Understand problems, opportunities, and constraints;
- ✓ Identify connects/ disconnects between resources, capabilities, and needs;
- ✓ Understand policies/ regulatory consistencies and inconsistencies; and
- ✓ Understand institutional/ jurisdictional challenges.

The process by which this information was collected was two-fold. First, a series of meetings were held with stakeholders in the watershed for the purpose of collaboratively identifying problems, needs, resources, goals, and current and desired mitigation activities. The USACE website (www.spl.usace.army.mil/virginriver.htm) contains the stakeholder meeting agendas, meeting notes, and presentations. Secondly, stakeholders were contacted individually via e-mail and by telephone. The stakeholders were asked about their and their respective agencies' roles, responsibilities, resources, regulations, capabilities, experience, communications, and needs. Available information was requested, collected, and reviewed (i.e., technical data and reports, spatial data, 2005 flood information, photos, and post-flood reports).

Section 3.0 of this report provides an overview of floodplain management within the Virgin River watershed. Section 4.0 summarizes on-going river management and related activities in the watershed. A GIS database containing the spatial data collected from stakeholders and other sources, with links to other work products, is provided under separate cover.

Flood Hazard and Risk Identification. Flood hazards and associated risks were identified and documented based upon information from the January 2005 flood experience, information provided by stakeholders, and previous technical work in the watershed. These hazards are categorized as follows:

- ✓ *Inundation.* – Development occurring within undesignated floodplains and floodways is subject to unknown levels of risk due to flood inundation. Floodplain regulations and drainage ordinances should be enforced in mapped flood zone areas to mitigate known risks. Areas subject to base-flood inundation should be identified and mapped.

- ✓ *Riverine Erosion.* – Development occurring adjacent to undelineated erosion hazard areas is subject to unknown levels of risk due to erosion. Erosion hazard regulations should be enforced in mapped erosion hazard areas to mitigate known risks. Areas susceptible to riverine erosion should be identified and mapped.

- ✓ *Sedimentation.* – Trends in channel sedimentation change in response to urbanization, floodplain encroachment, changes in watershed cover, and changes in channel vegetation. Flood and erosion hazards result from aggradation and degradation within the active channel and floodplain.

- ✓ *Debris Blockage.* – Both sedimentation and debris blockage of active channels, primary drainage structures, and roadway crossings create highly hazardous, rapidly changing conditions which can threaten public safety. Poor maintenance practices and unsystematic emergency communication protocols exacerbate the risks.

Section 5.0 describes the primary floodplain management issues related to the identified flood hazards. Section 6.0 addresses the lessons learned from the January 2005 floods, and documents the successes and the opportunities for improvement based on the experiences of stakeholders during that event.

Floodplain Management Goals. Given the background provided by stakeholder input, the 2005 flood experience, and the identified flood hazards and associated risks, floodplain management goals were formulated. These goals are intended to align with stakeholder needs, to leverage available resources, and to take advantage of collaborative opportunities. The resultant floodplain management goals are as follows:

- ✓ *Improve Communication.* – The goal is to improve both intra- and inter-agency communication between stakeholders in emergency and non-emergency situations.
- ✓ *Improve Floodplain Management.* – The goal is to implement measures for flood risk management to minimize hazard/ risk exposure.

Section 7.0 describes in further detail the strategic goals for floodplain management in the Virgin River watershed.

Mitigation Actions. – The next step in the work plan was to identify necessary action items to ensure, to the extent possible, that the established floodplain management goals are met. These action items are components of the hazard mitigation toolbox. The primary criteria for selection of mitigation actions were technical feasibility and cost effectiveness. A total of fourteen Mitigation Action items were selected, as follows:

1. Floodplain Management Handbook
2. Public Information Brochure
3. Contacts Database
4. Flood Response Plan
5. GIS Database
6. Flood Detection Network
7. Post-Fire Hydrologic Assessment
8. Floodplain Delineations
9. Erosion Hazard Delineations
10. Channel Conveyance Conservation
11. Floodplain, Floodway, and Erosion Hazard Zone Regulations/ Ordinances
12. Design Standards, Guidelines, and Publications
13. Streamlined Permitting Process/ Maintenance
14. Floodplain Management Strategy Steering Committee

A description of each Mitigation Action and its function in achieving strategic floodplain management goals is presented in Section 7.0. In addition, Mitigation Action reference materials are provided electronically on DVD, located in Appendix H.

Floodplain Management Strategy. The Mitigation Actions were purposefully selected to comprise the toolbox necessary to attain the floodplain management goals. The Mitigation Actions, or tools, were then organized to formulate a framework for each strategic goal. The tools were categorized as follows:

- ✓ *Information Resources.*
  1. Floodplain Management Handbook
  2. Public Information Brochure
  3. Contacts Database
  5. GIS Database
  14. Floodplain Management Strategy Steering Committee

- ✓ *Flood Warning System.*
  4. Flood Response Plan
  6. Flood Detection Network

- ✓ *Basic Data.*
  6. Flood Detection Network
  7. Post-Fire Hydrologic Assessment

- ✓ *Technical Resources.*
  8. Floodplain Delineations
  9. Erosion Hazard Delineations

- ✓ *Channel Conveyance.*
  10. Channel Conveyance Conservation

- ✓ *Regulatory Toolbox.*
  11. Floodplain, Floodway, and Erosion Hazard Zone Regulations/Ordinances
  12. Design Standards, Guidelines, and Publications
  13. Streamlined Permitting Process/Maintenance

The strategic goals comprise the Virgin River Floodplain Management Strategy (VRFPMS). The VRFPMS, in turn, is one component of the comprehensive Virgin River Watershed Strategy currently being prepared by the Corps. A diagrammatic representation of the interrelationship of Mitigation Actions, Floodplain Management Goals, and the Floodplain Management Strategy is presented in Figure 4.

The desired outcome of the VRFPMS is to address common goals, reduce flood risk, and remain compliant with the National Flood Insurance Program (NFIP). Section 7.0 further describes the VRFPMS.

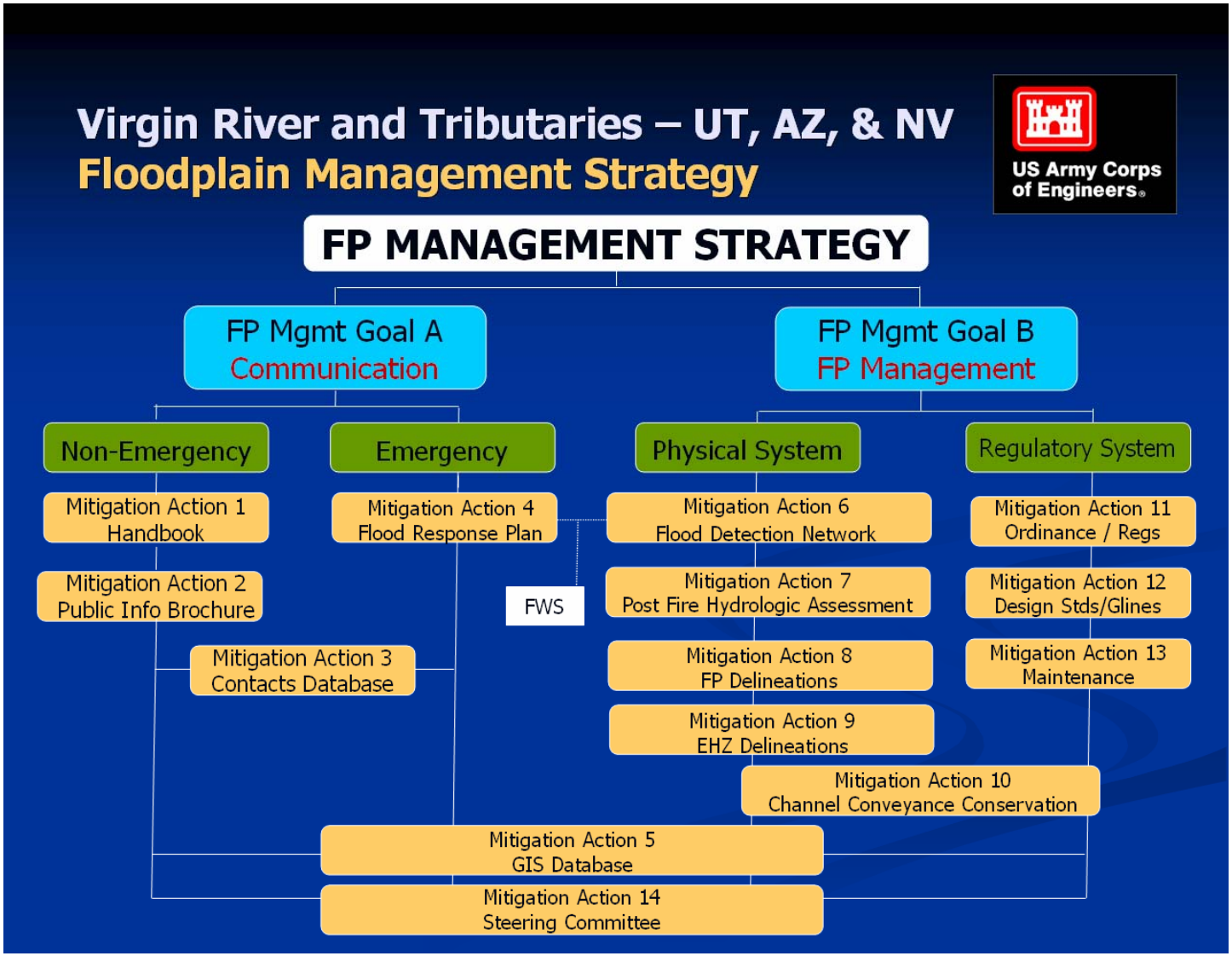


Figure 4 - Floodplain Management Strategy

Implementation Plan. The VRFPMS consists of fourteen Mitigation Actions which will require the collaboration, resources, and focus of a myriad of stakeholder agencies and entities. Clearly, a road map by which the VRFPMS will be implemented is necessary to facilitate a successful outcome(s). The purpose of the Implementation Plan is to be that road map. The Implementation Plan consists of the following elements:

- ✓ Short-, mid-, long-term priorities;
- ✓ Potential funding mechanisms;
- ✓ Progress milestone identification; and
- ✓ Recommendations for revisions/ updates to strategy.

An element of the Implementation Plan is to identify existing assistance programs and funding that could be evaluated for application specific to the VRFPMS Mitigation Actions. Also, certain technical data sources are available that could provide necessary basic data for implementation of the VRFPMS. The Implementation Plan is described in more detail in Section 8.0.

Communication Plan. One common theme heard from the stakeholders was the need for improved communications between and within jurisdictional agencies and with landowners, citizen groups, and the general public. The Virgin River watershed straddles federal agency regional limits, encompasses tribal lands, is located at the common boundaries of three states, and overlays six counties, several municipalities, and multiple unincorporated communities (see Figures 1 and 2). Given the diversity of jurisdictions, needs, and resources, there is clearly a need for a multi-faceted communication plan that functions in both emergency and non-emergency circumstances to: 1) facilitate multi-jurisdictional agency coordination and communication; and 2) provide a means for public education and awareness programs. The Communication Plan is described in more detail in Section 9.0.

In order to achieve these desired outcomes, an effective communication plan will require various components for use as information resources by stakeholders. The work products of several recommended VRFPMS Mitigation Actions directly relate to the communication plan. See Section 6.0 for more detailed descriptions of the Mitigation Actions.

- ✓ *Handbook* – The intent of the Floodplain Management Handbook (Mitigation Action 1) is to provide for informational continuity in the implementation of various action items, especially during times of transition in agency responsibilities and elected bodies.

- ✓ *Brochure* – The Public Information Brochure (Mitigation Action 2) is intended to communicate to the public useful information about flood and erosion hazards in their area, what they can do about mitigating their risk, and where to get more information.

- ✓ *Contacts Database* – A contacts database was developed during the formulation of the VRFPMS that is easily accessible and updatable (Mitigation Action 3). In order to facilitate use of the contact database by stakeholders in both non-emergency and emergency situations, the database was sorted by alphabetical order, agency name/type, state, and in the upstream/downstream direction along the Virgin River.

- ✓ *Emergency Communication Protocol* – A communication flowchart is a key work product of the Flood Response Plan (Mitigation Action 4). The flowchart is intended to clearly present communication links, means, protocols, and redundancies for use in emergency situations. A recommendation for successful implementation of the Flood Response Plan is to conduct regular training exercises which test the communication protocols and their robustness.

- ✓ *GIS Database* – Another useful communication tool for the exchange of spatial information relating to the Virgin River watershed is the Geographic Information System (GIS) database (Mitigation Action 5). A key consideration for both the contacts and GIS databases is that they must be hosted, maintained, and updated. The data collected for the GIS database include the following:

    - Land Ownership
    - County Boundaries
    - Municipalities
    - Cities and Towns
    - Quad Sheet Index
    - Watershed Delineations
    - Rivers and Streams
    - FEMA FIRM Maps Index
    - Floodplain Delineations
    - Erosion Hazard Delineations
    - Stream and Rain Gage Locations
    - Rainfall Data
    - Soil Survey Data and Index

- ✓ *VRFPMS Steering Committee* – It is recommended that a steering committee consisting of stakeholder representatives be convened on a regularly recurring basis for the purpose of maintaining effective communication and forward momentum in the implementation of the VRFPMS (Mitigation Action 14). It is envisioned that such a group would seek programmatic and funding assistance for the Mitigation Actions, monitor status/ progress of the VRFPMS Implementation Plan, and establish/ modify priorities as appropriate.

2.0 FLOODPLAIN MANAGEMENT OVERVIEW

2.1 Purpose

The management of floodplains represents the collective effort of a multi-jurisdictional consortium of federal, state, county, and local agencies; emergency management officials; research and education organizations; as well as public and private landholders. In application, the purpose of this task is to:

- ✓ Provide a consistent watershed framework for flood management;
- ✓ Develop regional floodplain management strategies;
- ✓ Establish implementation objectives; and
- ✓ Provide means of progressive improvement for floodplain management.

For this report, floodplain management is approached as a component of a broader watershed-based master planning process. While this VRFPMS report is designed and compiled as a stand-alone work, it is intended to function as a component of the comprehensive Virgin River Watershed Strategy which incorporates other aspects of watershed management. Additional programmatic inter-relationships are identified in the broader watershed master plan.

2.2 What is Floodplain Management?

At the broadest level, the purpose of floodplain management is to protect people and resources within floodplains. While one of the key components of the National Flood Insurance Program (NFIP) is the delineation of floodplains, floodplain management is not limited to those areas defined by FEMA as floodplains. Floodplain management is generally described as a decision-making process that aims to achieve the prudent and appropriate use of floodplains. Additionally, effective floodplain management requires policies that are compatible with the risks and resources inherent to floodplains to prevent or improve potentially costly or hazardous uses.

2.3 Management Strategy

The plan for the sustainable use of floodplains within the Virgin River watershed, and for the responsible management of their associated risks, includes the following:

- ✓ Identification of management responsibilities and concerns of stakeholders; collection of watershed data.
- ✓ Identification of pervasive flood hazards and flood risks among stakeholders.
- ✓ Assimilation of responsibilities, concerns, hazards and risks into floodplain management goals.
- ✓ Development of Mitigation Actions to achieve floodplain management goals.
- ✓ Organization of Mitigation Actions thematically into floodplain management strategies for progressive development.

- ✓ Empowerment of local communities' participation in flood risk abatement through development of specific floodplain management implementation activities. This includes identification of potential external funding sources.
- ✓ Development of a communication plan/ strategy to facilitate stakeholder cooperation.

2.4 Economic Impacts

Early settlement and economic development of the Virgin River basin were affected to a large extent by the floods of the late 1800s and early 1900s. Flood-related loss of farmland and damage to irrigation structures, dams, and dwellings were continuing problems for early settlers of the region (Larson, 1961). Major regional flooding has occurred along the Virgin River corridor in 1862, 1889, 1909, 1910, 1918, 1966 and 2005. The failure of the Quail Creek Reservoir dike on January 1, 1989 released about 25,000 acre-feet of water into the Virgin River near Hurricane, Utah causing an estimated $12 million in damages (ASDSO, 2007) and resulting in the highest discharge on record at the USGS gage near Littlefield, Arizona. A contemporary view of potential and actual costs associated with developments can be seen through flood hazard assessments and accounts of recent flooding (2005-2007), respectively.

Potential Impacts. Table 1 is an excerpt from the Five County Association of Government's Natural Hazard Mitigation Plan. It outlines properties and residents identified as within floodplains in Kane and Washington Counties, Utah.

Table 1 - Flood Hazard Assessment for Kane and Washington Counties, Utah
(Five County Association of Governments, Natural Hazard Mitigation Plan, 2003)

Location	# of People Residing in Flood Hazard Area	# of Structures in Flood Hazard Area		Value of Structures in Flood Hazard Area		
		Residential	Commercial	Residential	Commercial	Total
Hildale	16	2	0	$209,922	$0	$209,922
Ivins	1844	585	13	$70,802,222	$6,390,956	$77,193,178
La Verkin	35	11	0	$865,351	$0	$865,351
Leeds	3	1	0	$140,772	$0	$140,772
Rockville	30	14	0	$1,191,106	$0	$1,191,106
St George	2082	741	82	$85,083,763	$28,348,047	$113,431,810
Santa Clara	540	143	0	$18,921,243	$0	$18,921,243
Springdale	362	152	20	$15,967,013	$8,036,031	$24,003,044
Toquerville	23	7	0	$695,440	$0	$695,440
Virgin	70	56	1	$1,922,257	$233,359	$2,155,616
Washington	501	167	0	$16,171,629	$0	$16,171,629
Unicorporated Washington County	137	46	1	$4,914,377	$195,777	$5,110,154
Glendale	189	62	0	$4,017,611	$0	$4,017,611
Orderville	331	108	10	$6,506,444	$1,795,022	$8,301,466
Totals:	**6163**	**2095**	**127**	**$227,409,150**	**$44,999,192**	**$272,408,342**

The data provided in Table 1 account solely for properties within FEMA delineated floodplains and do not account for other floodplain hazards or circumstances not considered at the time of the applicable flood insurance studies. From this information, approximately $270 million of property and 6100 people within the Kane and Washington Counties portion of the Virgin River watershed are at risk from inundation hazards. For the communities listed in Table 1, this represents about 8% of the population at the time of the original study.

Recent Impacts. In response to regional flooding in 2005, $66 million was federally appropriated for NRCS Emergency Watershed Protection in Washington County. The long-duration events caused widespread lateral erosion of multiple watercourses. During these events, dozens of homes were damaged and 15 were destroyed completely in Washington County alone. During the same events in Mohave County, Arizona, 15 homes were lost in Beaver Dam and eight were flooded in Littlefield. Mohave County received $200,000 in EWP funds. Downstream in Mesquite, Nevada, 80 homes were affected and $2 million in damage to public infrastructure was sustained.

In August 2007, a flood event occurred in the vicinity of the Santa Clara River at Gunlock, Utah and on Lost Creek near Virgin, Utah. In Gunlock, although the flooding occurred in an area armored following the 2005 flood events, property damage was still sustained and abutments at the bridge crossing of the Santa Clara River immediately south of Gunlock were exposed. County Road 3184 (N. Gunlock Road) was closed due to a washed-out culvert north of Gunlock. In Virgin, approximately five homes were severely damaged by the event.

Future Impacts. Exposure to flood damage is not constant and depends on factors such as the level of development which occurs on floodplains. Without effective regulation of floodplain uses, the rate of growth of flood damage will likely increase.

Current estimates of flood damage costs are likely to be underestimated because of the lack of reliable data on property damage costs and because the estimates do not include the regional and social costs of flooding (intangible damages). These social costs are not readily measured in monetary terms and can persist for several years following a major flood event.

2.5 Natural and Beneficial Functions of Floodplains

Flooding is a natural phenomenon upon which a number of environmental benefits depend. Floodplains, waterways and their associated wetlands, have a fundamental role in supporting flora and fauna habitats of special significance. Floods replenish wetlands, transport food supplies and trigger stages in the life cycles of many plants and animals.

Floodplains provide natural overland flood flow paths and storage areas where floodwaters remain for slow release as river stage recedes, thereby reducing the potential for bank channel erosion from high energy flows. Nutrients, debris and sediment are

deposited during this process, protecting downstream reaches from higher sediment and nutrient loads and contributing to floodplain productivity.

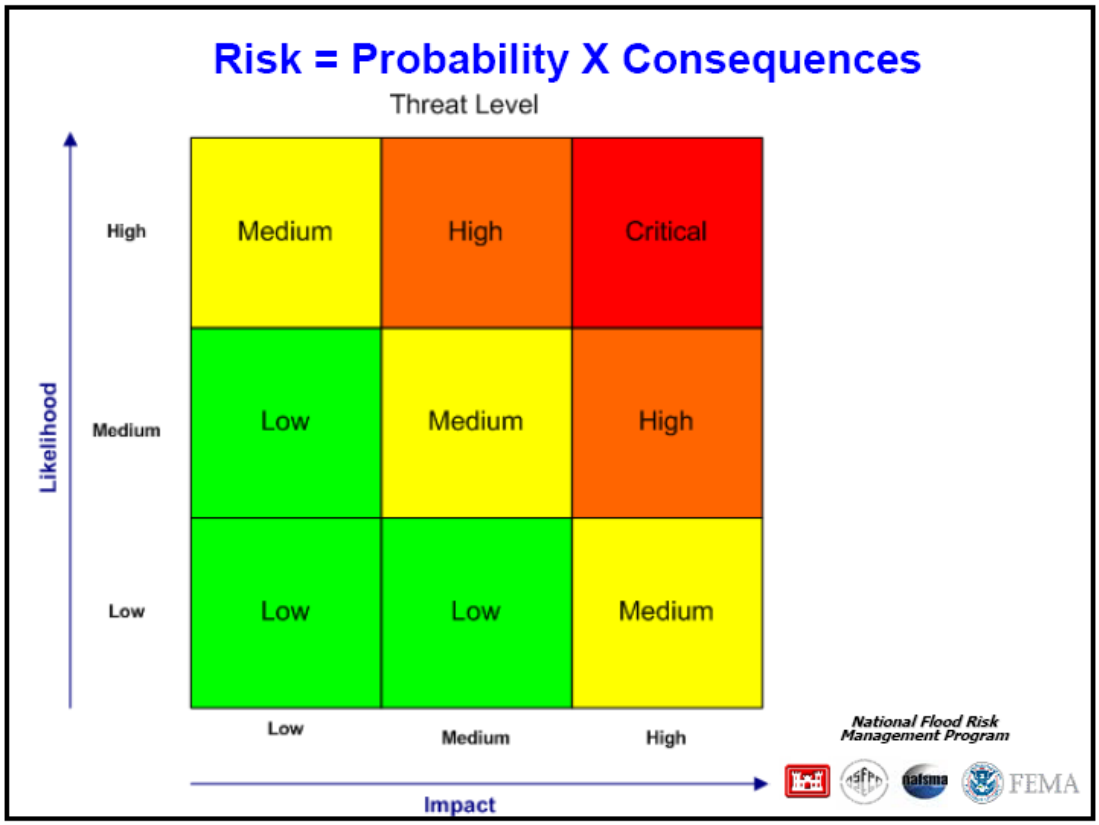
To manage the environmental values of floodplains effectively, reliable inventories of natural assets and an understanding of the environmental effects of a range of floodplain activities are required. These requirements are a necessary input to the implementation of flood management measures.

2.6 Flood Risk Management

Flood risk is defined as a flood hazard compounded with an asset. A typical example used to illustrate this concept is a rural floodplain on public land compared to an urban floodplain on residentially developed land. While the flooding hazard may be the same for both areas, the value of the asset increases the risk for the latter location.

Flood risk management is the progressive process of data collection; risk assessment; appraisal of options; and making, implementing, and reviewing decisions to reduce, accept, or redistribute risks of flooding. The interrelationships between risk management measures and their analyses, costs, and effectiveness within changing social, economic, and environmental settings are also of consideration.

Figure 5 - Flood Hazard Risk Assessment
http://www.spl.usace.army.mil/cms/files/projects/virginriver/FRMP_Update_08142007.pdf



A systematic assessment of probability and consequence benefits decision making about prioritization of Mitigation Actions needed to better manage flood hazard risk. As shown in Figure 5, the risk is directly proportional to the probability (likelihood) that a flood event of a certain level will occur and consequences (impacts) of the flood occurrence in terms of costs to public safety, property and the environment. Risk reaches critical levels when both the likelihood of the flood hazard and the impacts are at high levels.

Asset identification and valuation is a somewhat nebulous procedure. Commonly, a qualitative hierarchical assessment is first used to identify critical assets necessary for the public good. Following this, non-critical assets are valuated monetarily. While effective for hard infrastructure and structures, this methodology does not function well as a tool to evaluate habitat or resources of cultural value.

Flood hazards associated with the Virgin River watershed are primarily related to inundation, channel bank erosion or lateral migration, and dam breaks on reservoirs located on tributaries to the Virgin River.

2.7 Roles and Responsibilities

Effective flood management requires the coordinated involvement of landholders, property developers, communities, local authorities, municipal councils, state and government agencies, and other groups. A clear understanding of the respective roles and responsibilities of each group is essential for effective action.

At the coarsest level, the federal government is responsible for national flood management issues; the state government is responsible for statewide issues; counties and designated flood control agencies are responsible for countywide or regional issues; local government is responsible for local issues; and landowners are responsible for floodplain management on their own properties.

2.8 Regional Floodplain Management

Rivers, creeks, and other potential sources of flooding often cross jurisdictional boundaries (see Appendix A). To mitigate flooding across these boundaries a regional, watershed-based approach may be the most effective means of floodplain management. A broader scope offers the advantage of involving local governments, other public agencies, interest groups, landowners, and the general public throughout the watershed in a comprehensive, multi-jurisdictional program for reducing flood risk and potential damages and restoring and enhancing floodplain functions. The larger area may offer a wider range of potential policy and regulatory options than would be available in a single jurisdiction. Nonetheless, regional floodplain management is also more politically and logistically difficult than management undertaken within a single jurisdiction.

A regional floodplain management strategy provides states and counties with the planning framework for future flood related studies and projects within the region. It is the key document which clarifies and defines roles, responsibilities and cost sharing

arrangements for agencies, authorities and other stakeholders involved in floodplain management.

In developing regional floodplain management strategies, states and counties should define and detail responsibilities, funding and cost sharing arrangements for all flood management activities relevant to the region. This will be done through a process of regional negotiations and regional agreements between relevant stakeholders and in accordance with the broad principles set out in the Virgin River Watershed Strategy.

In particular, the regional strategy must strive to resolve regional versus local, rural versus urban, and upstream versus downstream challenges in relation to undertaking activities such as floodplain management plans, information management, flood warning and flood monitoring. The implementation of a particular activity will ultimately depend on the priority given to it in the regional strategy and the resources made available to fund that activity.

Successfully developing a regional floodplain management plan depends on the existence of several basic prerequisites, including the following:

- ✓ General recognition that there is a regional flooding problem that requires a solution;
- ✓ Impetus for the involvement of critical agencies and interest groups in the development of solutions;
- ✓ A person, group, or agency that will sponsor or champion the process;
- ✓ A range of feasible and practical solutions;
- ✓ Funding to pay for the necessary planning, as well as follow-up funding to implement the accepted plan; and
- ✓ Performance metrics to measure the effectiveness of plan implementation.

Few of the regional floodplain management efforts currently being implemented around the nation, including watershed management programs, are directly linked to city and county general plans. When possible, city and county planners and regulators should take an active, lead part in any regional floodplain management planning process. The local general plans, as well as zoning and subdivision ordinances, can play an important part in a comprehensive, multi-jurisdictional program for flood management. Cities and counties should amend their general plans and revise their zoning and subdivision ordinances when agreed as part of a regional effort.

Some tips for developing a Regional Floodplain Management Plan (adapted from U.S. EPA's "Top 10 Watershed Lessons Learned") are the following:

- ✓ Be sure that a watershed-based or risk-based planning process is needed and has broad community support.
- ✓ Invite all those with a stake in the outcome (landowners, residents, cities, counties, etc.) to participate.
- ✓ Establish a steering committee of community opinion leaders.

- ✓ Inform participants of the issues, problems, and a range of possible solutions.
- ✓ Identify sources of funding early in the process to help focus the range of potential actions.
- ✓ Respect the opinions of residents and other participants.
- ✓ Encourage a consensus approach, maintaining good communication among participants.
- ✓ Establish clear, measurable goals and feasible objectives.
- ✓ Assign responsibility, and funding, for specific aspects of the plan to each agency.
- ✓ Where possible, integrate floodplain management policies and regulations with local general plans, zoning ordinances, and subdivision ordinances.

3.0 OVERVIEW OF FLOODPLAIN MANAGEMENT WITHIN THE VIRGIN RIVER WATERSHED

The formulation of the VRFPMS is based upon the input received from stakeholders participating in the workshops and meetings and in the individual contacts. For a complete stakeholder contact listing, see the communication database provided in Appendix E. This section summarizes stakeholders' roles and perceived challenges and opportunities related to floodplain management in the Virgin River watershed.

3.1 Government Agencies and Roles

Based upon the information gathered from stakeholders, the following is a listing of governmental agencies and their roles as related to floodplain management in the Virgin River watershed.

3.1.1 Utah – State and Local

3.1.1.1 State

Name	Utah Department of Public Safety Division of Emergency Services and Homeland Security
Administrative	This agency administers the NFIP at the state level. The Division of Emergency Services is also the state sponsor for multiple federal pre-and post hazard mitigation grants. Wildfires and wildfire response fall under the Division's purview.
Regulatory	Agency responsibilities include regulatory compliance measures under the Hazard Mitigation Grant Program tied to funding from the Disaster Mitigation Act of 2000.

3.1.1.2 Local

Name	Five County Association of Governments
Administrative	The Association addresses regional issues such as wildfires and flooding from a planning perspective. Additionally, the Community Development Division provides rural development planning assistance and technical assistance to the Paiute Tribe of Utah.
Name	**Iron County**
Note	Little applicability to the Virgin River Watershed. No substantial development exists in the portion of Iron County which contributes to the watershed.

Name	Kane County
Operational	Maintenance and operation of facilities throughout Kane County.
Name	**Kane County Water Conservation District**
Operational	Maintenance and operation of water supply infrastructure.
Name	**Washington County**
Administrative	Participant in NFIP. Local sponsor of NRCS Emergency Watershed Protection program in 2005.
Operational	Maintenance and operation activities throughout Washington County.
Regulatory	Erosion hazard zone regulation enforcement.
Name	**Washington County Water Conservation District**
Operational	Maintenance and operation of District-run water supply infrastructure facilities. Streamflow gaging and monitoring. Virgin River Coalition. Environmental. Water Supply.
Name	**City of St. George**
Administrative	Participant in NFIP.
Operational	Maintenance and operation activities through Public Works Department.
Regulatory	Floodplain development requires approval of City Engineer.
Name	**City of Santa Clara**
Administrative	Participant in NFIP.
Operational	Maintenance and operation activities through Public Services Department.
Name	**City of Hurricane**
Administrative	Participant in NFIP.
Operational	Maintenance and operation activities.

Name	**City of Laverkin**
Administrative	Participant in NFIP.
Operational	Maintenance and operation activities.
Name	**Town of Leeds**
Administrative	Participant in NFIP.
Operational	Maintenance and operation activities.
Name	**Town of Toquerville**
Administrative	Participant in NFIP.
Operational	Maintenance and operation activities.
Name	**Town of Virgin**
Administrative	Participant in NFIP.
Operational	Maintenance and operation activities.
Name	**City of Washington**
Administrative	Participant in NFIP.
Operational	Maintenance and operation activities.
Name	**City of Kanab**
Administrative	Participant in NFIP.
Operational	Maintenance and operation activities.
Name	**Town of Glendale**
Administrative	Participant in NFIP.
Operational	Maintenance and operation activities.
Name	**Town of Orderville**
Administrative	Participant in NFIP.
Operational	Maintenance and operation activities.

3.1.2 Arizona – State and Local

3.1.2.1 State

Name	**Arizona Department of Water Resources**
Administrative	The Dam Safety Section administers Arizona's dam safety program. The Flood Mitigation Section performs floodplain management and administers NFIP programs at the state level.
Operational	The Flood Warning Unit is involved with the maintenance of Automated Local Evaluation in Real Time (ALERT) gages.
Regulatory	Develops State Standards for hydraulic design and hydrologic studies.
Financial	ADWR oversees the Water Protection Fund which furnishes funds for the "development and implementation of measures to protect water of sufficient quality and quantity to maintain, enhance, and restore rivers and streams and associated riparian habitat." (ARS, §45-12). Additional information is provided in Section 8.1.2
Name	**Arizona Division of Emergency Management**
Administrative	Administers federal hazard mitigation programs; specifically, the Hazard Mitigation Grant Program.
Regulatory	Included in the responsibilities under the Hazard Mitigation Grant Program are regulatory compliance measures tied to funding from the Disaster Mitigation Act of 2000.
Name	**Arizona Game & Fish Department**
Administrative	Management of watershed restoration through habitat and fishery restoration.
Operational	Maintains department dams and ALERT gages throughout the state.

3.1.2.2 Local

Name	Mohave County
Administrative	Floodplain management through the Mohave County Flood Control District and Public Works Department.
Operational	Operation and maintenance of facilities and capital project through the Public Works Department. The county maintains an ALERT system.
Regulatory	Mohave County flood control ordinances. A county hydrology and hydraulics design manual is being developed.
Name	**City of Colorado City**
Administrative	Participant in NFIP.
Operational	Maintenance and operations activities.
Regulatory	The City has an established floodplain use ordinance.

3.1.3 Nevada – State and Local

3.1.3.1 State

Name	Nevada Department of Conservation and Natural Resources
Administrative	Administers NFIP at the state level.
Operational	Dam inspections, water use inventories, water distribution activities.
Regulatory	Dam safety, well drilling, water usage and distribution activities.
Name	**Southern Nevada Water Authority**
Operational	Maintenance and operations of water delivery and impoundment infrastructure.

3.1.3.2 Local

Name	Clark County Regional Flood Control District
Administrative	Participant in NFIP.
Operational	Operation and maintenance of flood control facilities. CCRFCD operates and maintains Automated Local Evaluation in Real Time (ALERT) gages.
Regulatory	Enforces county-wide floodplain regulations. CCRFCD has also developed a Hydrologic Criteria and Drainage Design Manual.
Name	**City of Mesquite**
Administrative	Participant in NFIP.
Operational	Local maintenance is performed by the City of Mesquite Public Works Department.
Regulatory	The City and County utilize standard floodplain regulations and the City requires drainage studies with all new development.

3.1.4 Federal Agencies

Name	BLM
Location	Las Vegas Field Office
Administrative	Application of Las Vegas Field Office Resource Management Plan.
Operational	Maintenance and operations activities associated with roadways, habitat monitoring, and environmental science. They also have wildfire response and law enforcement capabilities. Capabilities reflect goals in Resource Management Plan.
Name	**BLM**
Location	**Arizona Strip Field Office**
Administrative	Application of Arizona Strip Field Office Resource Management Plan.

Operational	Maintenance and operations activities associated with roadways, habitat monitoring, and environmental science. They also have wildfire response and law enforcement capabilities. Capabilities reflect goals in Resource Management Plan.
Name	**BLM**
Location	**Kanab Field Office**
Administrative	Application of Kanab Field Office Resource Management Plan.
Operational	Maintenance and operations activities associated with roadways, habitat monitoring, and environmental science. They also have wildfire response capabilities. Capabilities reflect goals in Resource Management Plan.
Name	**BLM**
Location	**St. George Field Office**
Administrative	Application of St. George Field Office Resource Management Plan.
Operational	Maintenance and operations activities associated with roadways, habitat monitoring, and environmental science. They also have wildfire response capabilities. Capabilities reflect goals in Resource Management Plan.
Name	**FEMA**
Location	**Region VIII**
Administrative	Administers the National Flood Insurance Program and related flood hazard mitigation programs in Utah.
Operational	Conducts disaster relief operations.
Regulatory	Regulates community participation and compliance with the terms of the National Flood Insurance Program.

Name	**FEMA**
Location	**Region IX**
Administrative	Administers the National Flood Insurance Program and related flood hazard mitigation programs in Nevada and Arizona.
Operational	Conducts disaster relief operations.
Regulatory	Regulates community participation and compliance with the terms of the National Flood Insurance Program.
Name	**Bureau of Indian Affairs**
Location	**St. George Field Office**
Administrative	Administers federal grant programs to tribal groups. Also, informs tribal groups of the availability of assistance programs.
Operational	Law enforcement capabilities.
Name	**National Park Service**
Location	**Zion National Park**
Administrative	Manages property within National Park boundary to preserve park resources for future use while allowing for public use. Management practices conform to NPS Floodplain Management Directors Order and NPS Wetland Management Directors Order.
Operational	Park maintenance and operations functions.
Name	**NRCS**
Location	**Richfield Service Center**
Administrative	NRCS provides multiple programs including the Emergency Watershed Protection program, watershed surveys and planning, watershed operations, and watershed rehabilitation.

Operational	NRCS funding is available through several grant programs. Additional information is provided in Section 8.1.1
Name	**USFWS**
Administrative	Administers floodplain management and watershed restoration projects through fish and wildlife habitat projects.
Operational	Law enforcement capabilities.
Name	**USGS**
Administrative	Flood warning based on historical data. Regional regression estimates and watercourse and watershed studies.
Operational	The USGS monitors and maintains stream gages throughout the watershed.
Name	**USACE**
Location	**Regulatory Branch**
Regulatory	Administers Clean Water Act Section 404 permitting.
Name	**USACE**
Location	**Civil Works**
Administrative	Planning studies and design of capital projects in support of national and regional objectives.
Funding	USACE civil works programs are described in Section 8.1.1

3.1.5 Tribal

Name	**Kaibab Band of Paiutes**
Location	**Kanab**
Administrative	The Environmental Department oversees environmental permitting and regulation on tribal lands.
Operational	Operations and maintenance associated with tribal roads.
Name	**Shivwits Band of Paiutes**
Location	**Shivwits, UT**
Operational	Shivwits has historically maintained a wildland fire response force.

3.1.6 Other Entities

Name	**Virgin River Lands Preservation Association**
Location	**Las Vegas, NV**
Funding	Functions as a land trust to acquire property for “greenspace.”

3.2 Stakeholder Input Summary

One of the key outcomes of this study is to understand the current status of issues and needs related to floodplain management in the Virgin River watershed for the purpose of formulating goals for improvement. Mitigation Actions were then identified to address those goals and the specific issues of most concern to stakeholders. The following key points summarize the common concerns and perceived needs expressed by the stakeholders:

- ✓ *Hazard Assessment Needs*. Multiple flood hazards exist; including inundation, erosion, sedimentation (aggradation/ degradation), and debris blockage. Not all hazards are adequately addressed by the NFIP. There is a need for non-conventional flood hazard assessment (e.g., geomorphologic evaluation) that supplements more standard engineering, hydrologic, and hydraulic analyses methods.

- ✓ *Development-driven Priorities.* The pace and density of land development varies spatially along the Virgin River and tributaries. Rapidly developing areas are located in portions of the lower watershed including Clark County, Nevada; Mohave County, Arizona; and Washington County, Utah. Land development adjacent to and/or within floodplains and erosion hazard areas directly correlates to risk exposure and informs the prioritization of Mitigation Action items. Additional floodplain/ floodway delineations and erosion hazards zone delineations are needed in assessing development potential, risk, and priorities.

- ✓ *Leveraging Resources*. Small community needs differ from those of the larger communities. For example, many large communities already have in place floodplain and erosion hazard regulations, drainage ordinances, and/or design standards/ guidelines that function well for sound floodplain management. In general, they also have resources, albeit limited, to manage and enforce those regulatory instruments. Making available model regulations/ ordinances/ guidelines used in larger communities to smaller entities for review and adoption would be beneficial. This is one example of leveraging larger agency resources to serve regional floodplain management needs.

- ✓ *Collaborative Funding.* Related to the theme of leveraging resources, exploration of collaborative funding opportunities for vegetation management in conjunction with structural flood control measures is warranted. The programmatic funding sources for vegetation/ habitat management purposes are different from those available for flood control capital improvement projects. The concept is to pool resources to benefit overall watercourse form and function.

- ✓ *Information Resource Needs.* Communication is needed at the agency level for emergency and non-emergency purposes. However, there an equal need for

public outreach and education to help inform residents about flood hazards in their area, what they can do about it, and where to go for more information.

- ✓ *Flood Warning Needs.* The experience of the 2005 flood event demonstrated the need for a regional flood warning system to help agencies know about current emergency flood conditions, what to do and how to respond, and how much lead time they have to react. A regional flood warning system consists of flood response plans, communication plans, and an expanded flood detection network if needed.

- ✓ *Regulatory Inconsistencies.* Stakeholders were concerned about a perceived lack of consistency in permit review/ approval by regulatory jurisdictions, particularly at the federal level. There is a need for a streamlined process to help local agencies clear regulatory hurdles necessary for regular channel maintenance.

- ✓ *Environmental Needs.* A comprehensive Environmental Assessment (EA) or Environmental Impact Statement (EIS) may be in the critical path to triggering BLM or other federal agency resources for use in regional, watershed-based Mitigation Actions.

- ✓ *Channel Conveyance Conservation.* Conservation of channel conveyance should be accomplished by various means, including: vegetation management, sediment management, land use planning, regulatory enforcement, and application of sound design practices. Preservation of those reaches of the river that are functioning well in the natural condition is advocated.

3.2.1 Challenges

The implementation of Mitigation Actions required to address the information, resource, regulatory, and environmental needs identified by the stakeholders will face challenges. Key challenges are listed below:

- ✓ *VRFPMS Implementation Complexities.* The fact that multiple flood hazards exist speaks to the need for a multi-faceted mitigation toolbox. The challenge will be in managing the implementation of the various Mitigation Actions comprising the Floodplain Management Strategy along multiple sequential and parallel tracks. Diffusion of focus and resources could result without the oversight provided by a stakeholder steering committee.

- ✓ *Coordination with Virgin River Watershed Strategy.* Changes in watershed conditions directly impact floodplain management. The Floodplain Management Strategy is intended to be one component of the comprehensive Virgin River Watershed Strategy. Therefore, implementation of the VRFPMS Mitigation Actions will necessarily need to be coordinated with those for the Land Use Planning, Invasive Species, Water Supply, Watershed Management, and River Function components of the overall Watershed Strategy. The challenge will be in

coordinating, collaborating, and communicating across all work tracks to maximize efficiency and effectiveness in terms of resource investment and desired outcomes.

- ✓ *VRFPMS Updates.* Land use planning/ development directly impact floodplain management as discussed above. Flexibility in the VRFPMS will be necessary to respond to changing conditions in development pressures and pace, floodplain encroachment location, and imperviousness of watershed cover. The challenge will be to periodically review VRFPMS Implementation Plan and adjust the priorities and resource allocation as appropriate.

- ✓ *Multiple Jurisdictions.* Consistency in the application and enforcement of regulatory standards is a challenge, especially in consideration of the multiple jurisdictions within the watershed. To the extent possible, standardization of technical design standards/ guidelines, floodplain regulations/ ordinances, permitting processes/ outcomes will help to address this concern.

- ✓ *Facilitating Communication.* Communication is key to achieving the goals of the VRFPMS. In order to implement the Floodplain Management Strategy on a coordinated and consensus-driven basis, it is recommended that a steering committee comprised of stakeholder representatives be convened on a regularly recurring basis. The steering committee would seek programmatic and funding assistance for the Mitigation Actions, monitor status/ progress of the VRFPMS Implementation Plan, and establish/ modify priorities as appropriate.

- ✓ *Combining Resources.* Communities lack sufficient resources to address floodplain management issues at the local level. The challenge is coordinate and cooperate adequately to pool and leverage available resources and to take advantage of available existing programs and products.

3.2.2 Opportunities

Several opportunities to take advantage of in the process of implementing the VRFPMS were identified by stakeholders, including the following:

- ✓ *Existing Functional River Reaches*. Functional natural river reaches exist in the Virgin River watershed, creating opportunities for reach preservation.

- ✓ *River Restoration/ Maintenance.* River restoration/ maintenance activities are currently on-going (See Section 4.0). Opportunities exist to utilize current programs or expand them to implement and/or refine the VRFPMS Mitigation Actions and to inform design/ regulatory standards formulation.

- ✓ *Corridor Acquisition.* Opportunities exist for municipalities or other jurisdictions to minimize risk by acquiring lands located within the floodplain and erosion hazard zone corridors. These lands are appropriate for uses other than residential

and commercial development. Creating open space and providing recreational amenities, such as trails and/or parks, offers opportunities that benefit flood risk management efforts.

- ✓ *Existing Regulatory Tools.* Regulatory floodplain management tools are available. Opportunities exist to prepare floodplain delineations and to provide draft floodplain regulations, drainage and erosion hazard ordinances to communities currently without such tools.

- ✓ *Leveraging Programmatic Funding.* The potential for collaborative funding to combine resources/ programs to fund vegetation management in conjunction with structural flood control represents an opportunity to leverage available resources.

- ✓ *New Information Resources.* The need for educational outreach offers opportunities to use existing products or to develop new products, such as: databases/ informational materials and/or presentations for agencies, decision makers, and the public.

- ✓ *New Communication Tools.* Opportunities exist to streamline communication protocols through the use of existing products or new contacts and GIS databases as part of the Communication Plan.

4.0 OVERVIEW OF ON-GOING RIVER MANAGEMENT ACTIVITIES

Several on-going river management activities are underway in the Virgin River watershed. The Corps, as summarized previously, completed on-going flooding and floodplain management projects in the Virgin River Watershed Needs Analysis (under separate cover). These are listed in Table 2.

4.1 Virgin River Recovery Actions

There are numerous past, on-going, and potential recovery activities in the lower Virgin River watershed. These actions include Virgin River Fishes Recovery Team, SNWA funded activities (fish and birds), BLM funded actions (e.g., tamarisk removal, fish barriers), NDOW (e.g., tilapia control), and Proposed Virgin River Habitat Conservation and Recovery Program (VRHCP). Proposed VRHCP is to provide an ESA compliance mechanism for development and to identify and implement recovery actions for three species of birds and two species of fish. Participants include USFWS, NPS, BLM, NDOW, SNWA, Clark County, Virgin Valley Water District, and City of Mesquite.

4.2 Virgin River Master Plan

Following flooding in January 2005, the Washington County Water Conservancy District, in collaboration with St. George City, Washington City, and Santa Clara City contracted to prepare a Comprehensive Master Plan to provide river management tools for both immediate and future activities along the Virgin River, Santa Clara River, and Ft. Pierce Wash in the incorporated areas of Washington County, Utah. Documents related to this work, as well as others, are available at the following link: http://wcwcd.state.ut.us/Plans,%20Studies%20&%20Reports.htm

Lessons learned from the Virgin River Master Plan include the following:

- ✓ River management is a regional issue and will require cooperation from all the local entities;
- ✓ Specific guiding principles and recognized design standards should guide all reconstruction, management, and maintenance of the Virgin River and tributaries;
- ✓ Regulating development within floodplain and erosion hazard zones prevented additional damage from occurring during the 2005 flood event; and
- ✓ Standard FEMA Floodplain Management Regulations are not sufficient to protect property from erosion damage.

Table 2 - Previous Virgin River Watershed Flooding/Floodplain Management Reports
(Source: USACE Virgin Rive Watershed Needs Analysis, 2007)

Title	Author/Date	Availability	Subject
Arizona			
DRAFT Hydrologic Analyses: Portions of the Virgin River and Beaver Dam Wash Mohave County, AZ	FEMA Region IX, January 2006	FEMA, Mohave County	Presents the methodology and results of the hydrologic analyses performed for a portion of the Virgin River and Beaver Dam Wash in the Littlefield Area of Mohave County, Arizona. The results of these hydrologic analyses will be used in the hydraulic analyses to develop flood information for use by FEMA in making determinations regarding potential Hazard Mitigation Grant Program (HMGP) projects.
Mohave County Flood Control Ordinance-2000	Mohave County Flood Control District	Mohave County Flood Control District	County flood control ordinance
Beaver Dam Wash Flood Hazard Assessment Report	Arid Hydrology & Hydraulics, LLC, December 2007	Mohave County Flood Control District	Evaluates flood risks and hazards to existing homes in detailed study area near the Town of Beaver Dam, AZ.
Nevada			
Mesquite Flood Control Master Plan Update (MPU)	Clark County Regional Flood Control District, 2007	http://breccia.ccrfcd.org/FileLibrary/FileLibrary.aspx	The 2007 MPU serves as a planning tool for the implementation of the flood control system in Mesquite and for the design and construction of master plan facilities. The flood control system identified and described in this MPU may be subject to further amendments and revisions in the future as more detailed analyses are completed for facilities in the pre-design and design phases.
Town of Bunkerville Flood Control Master Plan Update	Clark County Regional Flood Control District, 2007	http://breccia.ccrfcd.org/FileLibrary/FileLibrary.aspx	The 2007 MPU is a planning tool for use by public agencies, land planners, and various other entities. It provided updated information concerning the comprehensive flood control plan. The document presents information and analyses that went into the update. Bunkerville is impacted by several washes that discharge to the Virgin River.

Title	Author/Date	Availability	Subject
Draft Conceptual Framework for Development of the Virgin River Flood Control and Restoration Measures Long-Term Plan	City of Mesquite, Mar 2005	City of Mesquite	The goals are to reduce the risk of flooding to structures and infrastructure within City of Mesquite, to reduce the potential for lateral and vertical channel instability and resulting erosion of stream banks during high-flow events that can threaten homes, land and infrastructure, and to restore natural fluvial processes in order to provide appropriate aquatic and riparian critical and optimal habitat for listed species.
Virgin River Flood Insurance Study, Request for LOMR	Clark County Regional Flood Control District, May 2006	http://breccia.ccrfcd.org/FileLibrary/FileLibrary.aspx	Area experienced a major flood event near the magnitude of a 0.01 frequency event in January, 2005. During this event, the flooding limits were wider than the mapped 100-year regulatory Special Flood Hazard Area, which caused more than $1 million in public infrastructure damages and damaged approximately 80 homes. Therefore, this LOMR recommends needed revisions to the existing FEMA flood zone delineation shown on the Flood Insurance Rate Maps (FIRMs) for the City of Mesquite and Clark County.
Virgin River Flood Study, Geomorphic Analysis Report Virgin River at Mesquite	Clark County Regional Flood Control District, Oct 2006	http://breccia.ccrfcd.org/FileLibrary/FileLibrary.aspx	Analyzes the river's response to the January 2005 floods in the context of historical information, synthesizes this information to provide insight into potential future behavior of the river system, and provides recommendations for future river management practices.
Virgin River Flood Hazard Study: Erosion Protection Report	Clark County Regional Flood Control District, January 2007.	http://breccia.ccrfcd.org/FileLibrary/FileLibrary.aspx	Report presents alternatives for alignment of potential erosion protection including bank protection and other structures along the Virgin River in the vicinity of Mesquite and Bunkerville, NV.
Utah			
River Stability Study, Virgin and Santa Clara Rivers	Washington County, City of Santa Clara and City of St. George, Sept 2005	http://wcwcd.state.ut.us/	In response to the damaging floods in January 2005, completed a river stability study as part of a Master Plan, which included a geomorphic evaluation of the Santa Clara and Virgin Rivers. The report concludes with five recommendations, mostly focused on land use.

Title	Author/Date	Availability	Subject
Fort Pearce Wash Master Plan: A roadmap for reconstruction, management, and long term maintenance.	Washington County Water Conservancy District. April 2007	http://wcwcd.state.ut.us/	Extreme flooding in Washington County and Southern Utah during January 2005 revealed potential vulnerabilities to flood and erosion hazards and highlighted the need for coordinated master planning along the major river systems. Plan goals are to optimize the function and stability of Fort Pearce Wash in order to minimize risk of erosion and property damage from future floods.
Fort Pearce Wash River Mining Plan	Washington County Water Conservancy District. March 2007	http://wcwcd.state.ut.us/	As part of the Maser Plan this document is intended to assist establishment of mining guidelines to be used to regulate instream mining primarily along Ft. Pearce Wash and to assess likely impacts to flood and erosion hazards along the wash corridor. Objectives are to allow for the production of aggregate while minimizing the potential for flood and erosion damages to the local community and to the environment.
Virgin River Stability Study Update	Washington County Water Conservancy District. March 2007	http://wcwcd.state.ut.us/	As part of the Maser Plan this document consisted of a geomorphic evaluation of the Virgin River from its confluence of the Santa Clara River to the Washington Fields Diversion Dam. It extends erosion hazard delineations previously determined in a 1997 study.
Master Plan: A road map for reconstruction, management, and long-term maintenance. Santa Clara River, Washington County, Utah	Washington County Water Conservancy District. September 2005	http://wcwcd.state.ut.us/	The primary goal of the Master Plan is to minimize the risk of flooding and bank erosion along the Santa Clara and Virgin Rivers. The Master Plan recommends specific protocols for the reestablishment of stream channel, floodplain, and terrace features; the revegetation of the riparian areas for stability and wildlife and addressing appropriate future land use along the rivers. It also recommends a long-term maintenance program to ensure project objectives are achieved.
Virgin River Master Plan: A road map for reconstruction, management, and long-term maintenance. Virgin River, Washington County, Utah	Washington County Water Conservancy District. Revised July 2007	http://wcwcd.state.ut.us/	The Master Plan goals are to optimize the function and stability of the Virgin River to minimize the risk of erosion and property damage from future floods. It recommends specific stream stability protocols for the reconstruction of stream channel, floodplain, and terrace features; revegetation of the riparian areas for stability and wildlife and appropriation of future land use along the rivers. The Master Plan also recommends a long-term maintenance program to ensure project objectives are achieved.

Title	Author/Date	Availability	Subject
Five County Association of Governments Natural Hazard Mitigation Plan A Regional Approach for Southwestern Utah	Five County Association of Governments	http://des.utah.gov/nathaz/pdm_pub_st.htm	The goal of this plan is to assist the five counties of Southwestern Utah, in reducing the costs of natural disasters; namely Wildfire, Landslide, Flood, Earthquake, Volcanoes, Drought, Problem Soil, Severe Weather, Insect Infestation, and, Radon Gas through mitigation practices. This plan provides comprehensive hazard identification, risk assessment, vulnerability analysis, mitigation actions, and implementation schedule for the region.
Flood in Virgin River basin, Southwestern Utah, January 9-11, 2005	USGS, 2006 Online	http://ut.water.usgs.gov/FLOODING/Virgin_flood.htm	Estimates of instantaneous peak discharges at U.S. Geological Survey (USGS) streamflow-gaging stations for the Virgin River Basin flood of January 9-11, 2005, are provided below. Recurrence interval discharge estimates were computed for each streamflow-gaging station by using two techniques.
Flooding and Stream flow in Utah during water year 2005	USGS, 2005	http://pubs.usgs.gov/fs/2006/3085/	The 2004 and 2005 water years illustrate why water managers in Utah generally describe the water supply as 'feast or famine.' In September 2004, Utah was finishing its sixth year of drought. The 2005 water year brought with it a significant change in the weather, beginning with intense rainfall in the Virgin River basin of southwestern Utah. Only minor flooding resulted from this storm; however, it provided soil moisture that would contribute to severe flooding during January 2005.
Flood Plain Information – Virgin River and Fort Pierce Wash, Vicinity of St. George	US Army Corps of Engineers (USACE) Apr 1973	USACE	Identifies areas that are subject to future flooding for consideration in land use planning.
Hydrology for Evaluation of Proposed Water Supply Reservoirs	USACE, Aug 1988	USACE	Presents reconnaissance level hydrology examining the incidental flood control of two proposed water supply reservoirs in the Upper VR watershed.
Virgin River and Tributaries at St. George, Utah, Section 205 Reconnaissance Study	USACE, May 1991	USACE	Considers several alternatives to eliminate or reduce these damages, including, floodproofing structures at risk, installing FWS, constructing earth levee system, modifying existing channel and constructing detention basin upstream of at risk area.

Title	Author/Date	Availability	Subject
North Fork of the Virgin River Town of Springdale, Utah Section 206 – Special Study Floodplain Mgmt Services	USACE, Jan 1996	USACE	Provides hydrologic, hydraulic and nonstructural flood plain information for local official use in planning and regulation of the flood plain.
Floodplain Management in Utah Quick Guide	Utah Division of Emergency Services & Homeland Security, 2003	Utah Division of Emergency Services & Homeland Security	State of Utah's flood hazard and mitigation reference guide for property owners.
Other			
Virgin River Watershed Comprehensive Watershed Analysis Utah, Arizona and Nevada (Draft)	USACE, January 2008	USACE, Draft report subject to limited distribution	Comprehensive, multi-disciplinary watershed management strategy for the Virgin River Watershed. The parent document of the Virgin River Floodplain Management Strategy (this document).

4.3 Virgin River Program

This is a multi agency program with the following goals:

- ✓ Implement actions to recover, conserve, enhance, and protect native species in the Virgin River; and
- ✓ Enhance the ability to provide adequate water supplies for sustaining human needs.

The website for the program is http://www.virginriverprogram.org

Recovery actions within the Virgin River Program include the following:

- ✓ Restore water to the river channel;
- ✓ Place fish screens on diversions;
- ✓ Maintain native fish brood stock at hatcheries and stock in the river;
- ✓ Improve natural river processes;
- ✓ Eliminate nonnative fishes from river (physical removal and rotenone treatments);
- ✓ Identify and address factors that limit native fish populations (temperature, turbidity, low flow, flow variability, habitat); and
- ✓ Public outreach and education.

4.4 NRCS Rapid Watershed Assessments

The Natural Resources Conservation Service (NRCS) National Strategic Plan focuses on natural systems as key to conserving natural resources and encourages collaborative efforts to maximize results. NRCS will provide services such as technical assistance, technology, information, and programs on a watershed basis. Rapid Watershed Assessments (RWA) provide initial estimates of where conservation investments would best address the concerns of landowners, conservation districts, and other community organizations and stakeholders. These assessments help landowners and local leaders set priorities and determine the best actions to achieve their goals. Eight RWAs have been completed in the State of Utah. The RWA's can achieve the following tasks:

- ✓ Provide information to develop business plans and strategies;
- ✓ Assist NRCS and others obtain technical and financial assistance;
- ✓ Provide information to help program managers and decision makers;
- ✓ Provide focus for forming effective partnerships;
- ✓ Lead to more detailed, comprehensive assessments and plans where needed to solve resource issues;
- ✓ Seek and promote cooperative efforts to achieve conservation goals;
- ✓ Facilitate the growth of market-based opportunities that encourage business and industry to invest in conservation on private lands;

- ✓ Provide information and assistance to encourage and enable locally led, watershed-scale conservation.

4.5 Virgin River Conservation Partnership

The Virgin River Conservation Partnership seeks to balance the conservation and restoration of the Virgin River ecosystem with economic development, while prompting ecological sustainability, economic viability, responsible use and stewardship, and long term community benefits. Note that the partnership has ongoing meetings and information can be located at http://dev.fargeo.com/vrhcp .

5.0 FLOODPLAIN MANAGEMENT ISSUES IN THE VIRGIN RIVER WATERSHED

Unlike humid regions, the flood and flood-related risks experienced in arid and semi-arid regions can shift dramatically because these watersheds can be unstable. There is a need to expand traditional risk mapping to include erosion, distributary flow systems, post-wildfire conditions, debris and mud flows, effects of urbanization, and invasive plants.

Within the Virgin River watershed, issues ranging from land use to wildfire severely impact floodplain management. In addition to the floodplain management needs, challenges, and opportunities identified by stakeholders and summarized in Section 3.2; the following general influences on floodplain management have been identified by stakeholders as significant within the Virgin River watershed.

5.1 Wildfires

In the western United States, wildfires are a common occurrence. Figure 6 illustrates the recent fire impacts to subwatersheds within the study area. Wildfires destroy and impair the function of vegetation and soils, effectively altering the land-use characteristics of a watershed. Probable hydrologic and geomorphic impacts include:

- ✓ An increase in runoff magnitudes and volumes.
- ✓ An increase in soil erosion.
- ✓ Greater reservoir and channel sedimentation.
- ✓ Changes in channel morphology.
- ✓ Increased avulsion potential due to sedimentation and debris blockage.

The rainfall-runoff response characteristics of a watershed are defined by several factors. However, the two most influential characteristics are ground cover/ vegetation and the soil matrix. These characteristics are highly impacted by wildfires that rapidly alter ground cover and the surface soils. Affected aspects of both are discussed in greater detail below.

5.1.1 Impacts to Ground Cover/Vegetation Resulting from Wildfires

Canopy and areal ground cover create initial precipitation interception by plants. The presence of a vegetated canopy also acts to reduce rainfall intensity by convoluting the path of the precipitation to the ground. Grasses and low lying plants retain water through increased roughness. Further, root structures create preferential infiltration paths for runoff. By destroying or impairing these functions, wildfires increase runoff.

The loss of ground cover causes an increase in surface soil erosion. Increased sediment yields create the potential for other hazards such as debris flows and bulking of flood flows.

A loss of vegetation decreases the surface roughness. Decreased roughness allows water to move more quickly over the ground surface and reduces the contact time water has before reaching a drainageway. The loss of roughness effectively increases hydrographic peaks and increases the frequency of flow events.

5.1.2 Impacts to Soils Resulting from Wildfires

Following wildfires, surficial soil erosion is most exacerbated on hillslopes where the sediment-carrying capacity of runoff is more likely to increase over the transport threshold of the surface soils.

Surficial soil porosity within a post-fire area can be reduced by the presence of ash, which decreases the infiltration rate of the soil. In addition, soil structure can be impaired through a loss of organics and change in structure, which also reduces infiltration rates.

5.2 Erosion, Sediment, and Debris Hazards

5.2.1 Erosion Hazard

One third of the nation's streams experience severe erosion problems, resulting in almost 450 million dollars in erosion-related damages per year (FEMA, 1999). In a study of riverine erosion hazards, the Federal Emergency Management Agency (FEMA, 1999) specifically noted that lateral erosion in Arizona occurs to such a degree that areas outside of the designated 500-year floodplain have collapsed into the main channel due to lateral channel movement. Past and recent studies in the Virgin River watershed in Washington County, Utah, and Clark County, Nevada have documented 10's to 100's of feet of channel bank erosion during single floods (CH2M HILL, 1997; JE Fuller/Hydrology & Geomorphology, Inc. (JEF), 2005, 2007a, 2007b). This resulted in the destruction and/or damage to public infrastructure (roads, bridges, utilities, etc.), public and private land, and public and private structures (homes, businesses, public parks, etc.) with costs in the hundreds of millions of dollars. Figure 7 shows an example of the result of bank erosion on the Santa Clara River within the City of St. George, Utah during the January 2005 flood.

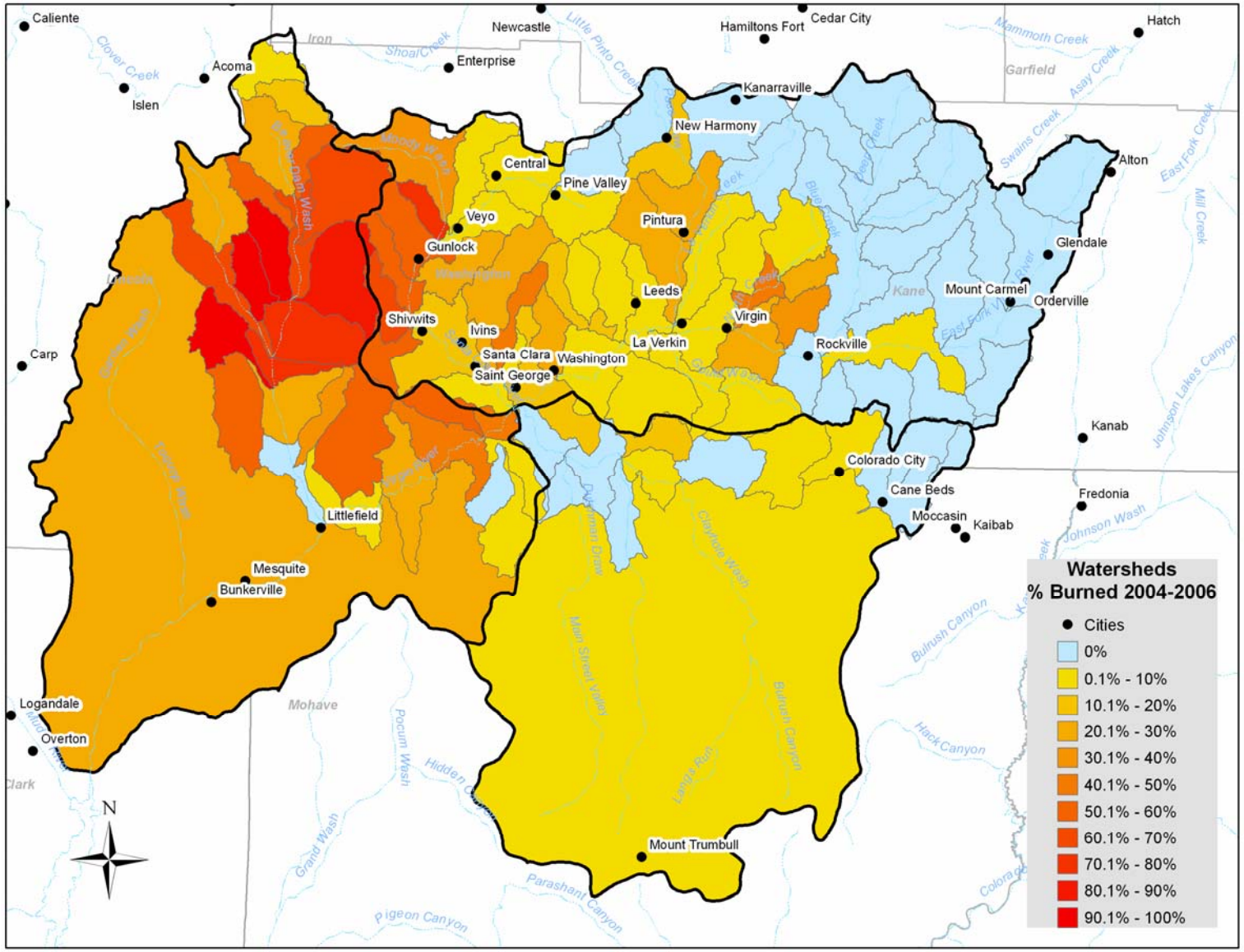


Figure 6 - Percent of Subwatersheds Burned 2004-2006

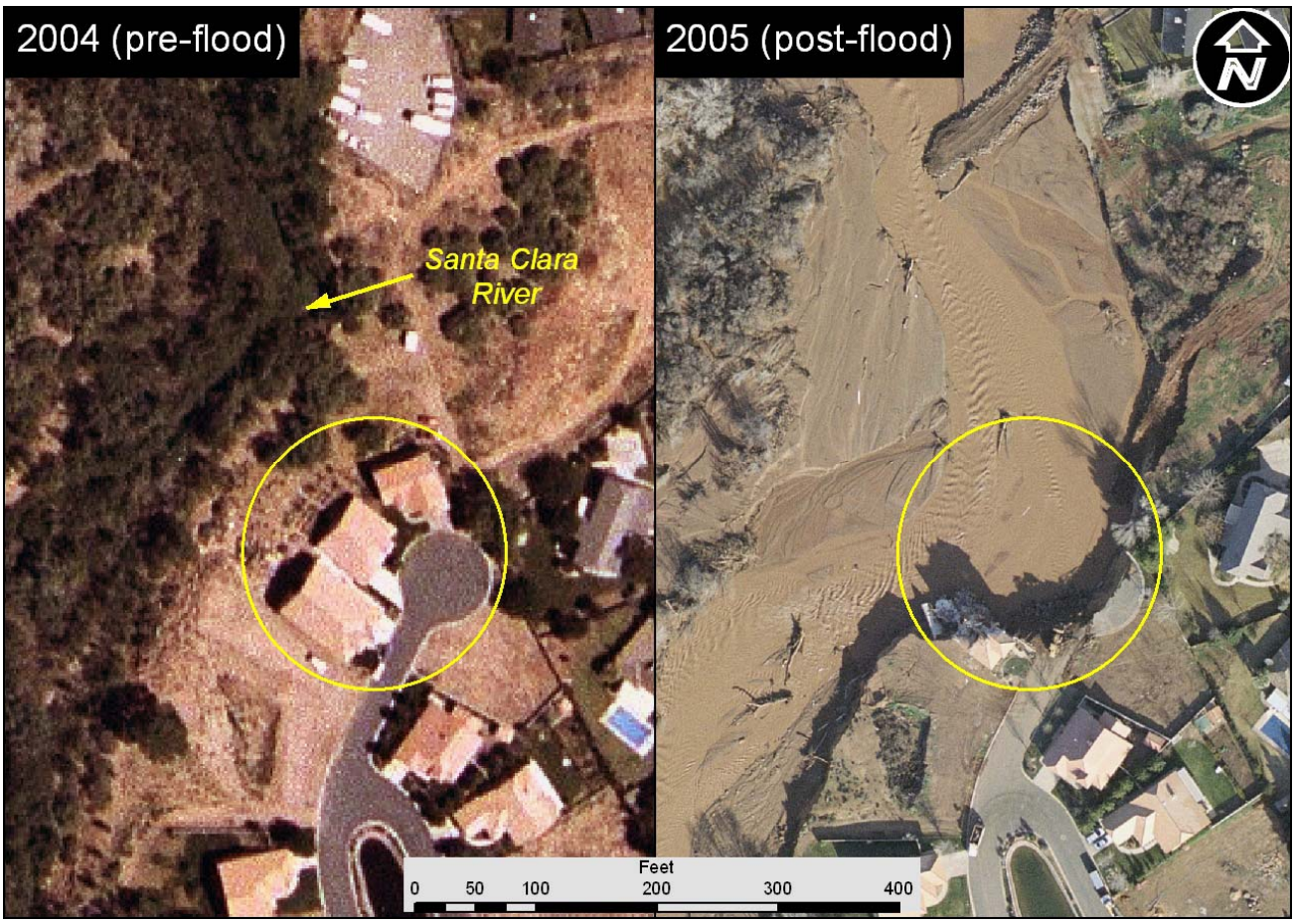


Figure 7 - Santa Clara River Bank Erosion

5.2.2 Vegetation Debris

Much of the Virgin River floodplain is dominated by tamarisk (*Tamarix*), an invasive, non-native plant whose impacts on riverine ecosystems and morphology has been well documented (Horton, 1977; Graf, 1978; Baum, 1978; Kunzmann et al., 1987; and others), and is discussed in detail in Section 5.4.1 of this report. Dense stands of tamarisk substantially reduce conveyance capacity of an active river channel during large magnitude floods, often resulting in channel avulsions and concentrations of overbank flows which erode floodplain sediments and inundate structures outside the regulatory floodplain. Figure 8 shows a comparison of the Virgin River floodplain in Mesquite, Nevada in 1938 (pre-tamarisk invasion) and 2004. Note the wide active channel and sparse floodplain vegetation in 1938 contrasted with the overly-narrow active channel and tamarisk-choked floodplain in 2004.

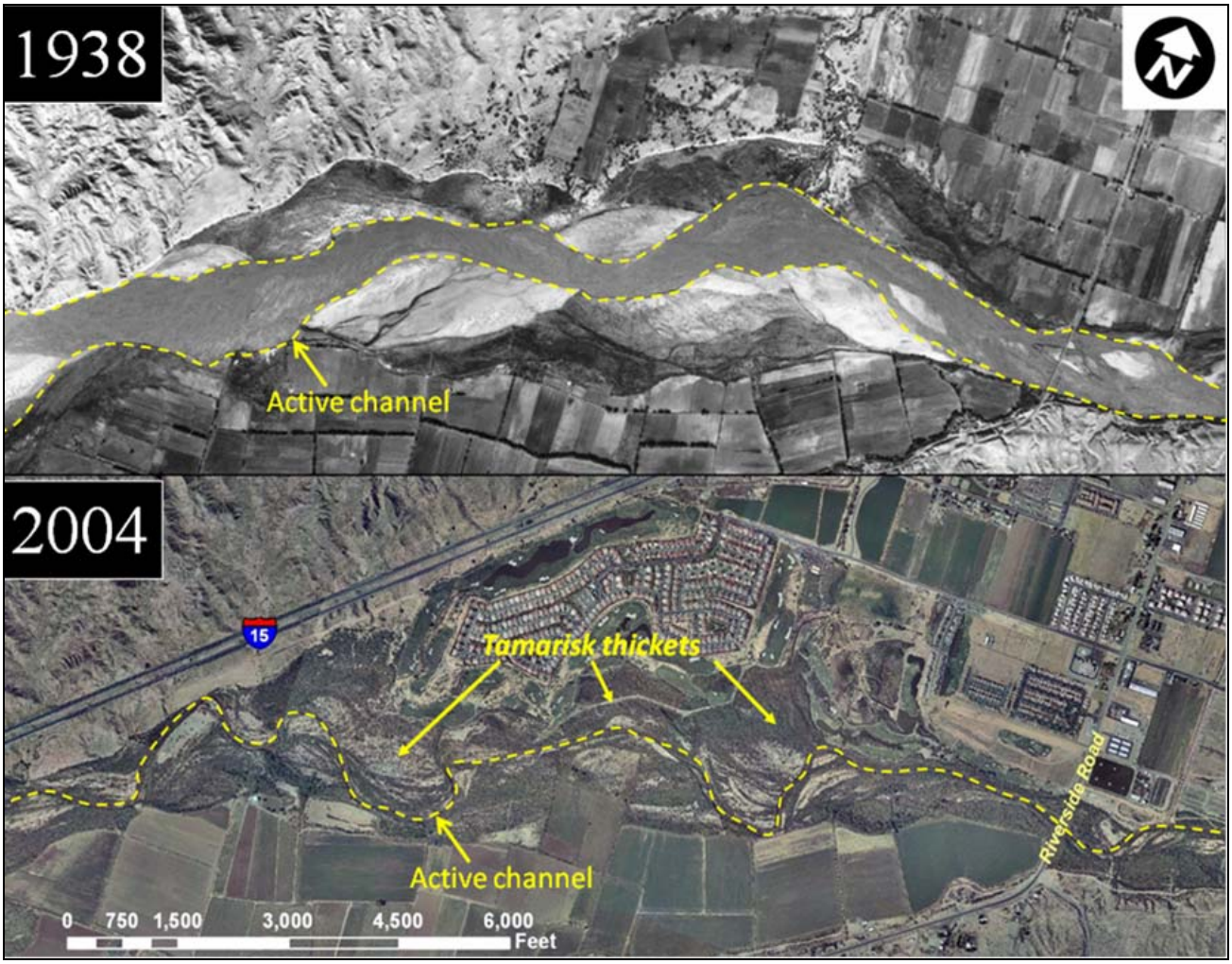


Figure 8 - Virgin River Floodplain Vegetation Comparison

Additionally, dense floodplain stands of tamarisk provide an abundant source of debris as the plants are entrained into flood flows during large magnitude events. During such events, the active channel erodes its banks in an attempt to create a conveyance corridor sufficient to convey the flood flows. Entrained vegetation creates adverse impacts as it becomes trapped behind structures such as bridges and culverts, removing conveyance area and causing flows to overtop and potentially erode the structure thereby compromising public safety. Heavy debris-laden flows can also result in in-channel debris dams that can divert flows resulting in accelerated bank erosion or channel avulsions. Overly dense native vegetation, such as cottonwood trees, can also result in adverse floodplain impacts during large magnitude flood. A dense stand of cottonwoods can also significantly reduce channel conveyance which can cause the formation of debris dams resulting in channel avulsions. A single, mature cottonwood tree 20 feet in height that has become entrained in flood flows can initiate a debris dam if it encounters a dense stand of cottonwood trees which have less than 20 feet of horizontal clearance. Combining large debris such as a cottonwood tree with the abundant volume of tamarisk available for flood debris can result in significant debris conveyance problems during floods.

5.2.3 Sediment

Both sediment accumulation (aggradation) and removal (degradation) occur naturally in river channels and floodplains. Sediment is transported through the system if the river maintains an adequate amount of energy. If that energy is lost through a reduction in channel slope, expansion of channel width, or increased channel roughness, then sediment is deposited. If the river system contains excess energy due to lack of sediment, increased channel slope, or channel contraction then sediment is captured in the flow by eroding the channel banks or scouring the channel bed. Although these processes occur naturally, they can be accelerated by changes to the watershed such as urbanization (Section 5.3), fire (Section 5.1), and cyclical changes to climate (increased precipitation or drought).

Aggradation. Aggradation, or sedimentation, increases the water surface elevation and forces flow onto the floodplain, where it creates new channels and flow paths (avulsions). Aggradation of the active channel can be a gradual, long-term process spanning multiple years which may go undetected until a large magnitude flood results in an avulsion. The dense vegetation characterizing much of the Virgin River floodplain, as described previously, creates an ideal situation for long-term aggradation. Significant aggradation can also occur during a single flood event as flood waters exceed the channel capacity and inundate the floodplain. Figure 9 shows examples of floodplain aggradation that occurred on the Virgin River during the January 2005 flood.

Virgin River left-overbank floodplain downstream of Man-of-War Road Bridge in St. George, Utah. Note the amount of sediment on the right side of the photo that has been stockpiled. View is upstream direction.

The same location looking across the surface in the easterly direction. Again note the abundant volume of sediment that has been removed from the floodplain and stockpiled.

Figure 9 - Example of Floodplain Aggradation

5.2.4 2005 Virgin River Flood

The Virgin River watershed experienced large floods in January 2005. Lateral channel erosion within Washington County, Utah resulted in damage to or complete loss of 17 homes, with an additional nine homes classified as "unsafe" following the floods. Four bridges were completely destroyed by the floods, and eleven more were substantially damaged.

In a watershed context, the flooding in 2005 is significant because of the regional nature of the event, amount of damage sustained, and varied nature of the flood hazards. While the upper watershed sustained relatively little damage due solely to inundation and experienced peak discharges associated with a relatively low recurrence interval, the lower watershed experienced greater inundation damage and discharges associated with larger return interval events. In spite of these regional differences in behavior, debris accumulation and avulsion were experienced throughout the watershed. A description of impacts follows.

Santa Clara River. The CH2M Hill (1997) study concluded that the Santa Clara River at that time was characterized by historical channel degradation resulting in over-steepened, unstable banks with a high potential for lateral erosion when no bank stabilization existed. Post-2005 flood field observations indicated that although the river behaved as predicted in the 1997 study, the magnitude of change was greater than could have been anticipated based on historical records.

Without exception, the entire active channel corridor from Gunlock, Utah to the Virgin River confluence was modified by the 2005 flood. Observed changes to the low-flow channel included: the removal of vegetation from channel banks, widening of channel banks, channel avulsions, areas of local aggradation and degradation, and accumulation of debris. Observed changes to overbank and floodplain areas included development of avulsion channels, removal of vegetation, sediment deposition, scour, and debris accumulation.

Anecdotal information provided by City of St. George officials (J. Sandburg personal communication, 2005) suggested one of the causal mechanisms for abrupt changes in channel bank location was debris dams within the active channel. Evidence of this mechanism was observed during post-flood field investigations. Figure 10 is a photograph of a debris dam that resulted in a channel avulsion which created a new thalweg alignment through a former floodplain, and resulted in lateral migration of the active channel corridor. Once abandoned, the pre-flood active channel began to function as a floodplain with up to six feet of sediment accumulation observed. Figure 11 illustrates another location where a debris dam was likely the cause of significant lateral erosion (debris was not present at the time of the field investigation; however, City officials indicated a debris dam formed during the flood). Debris also accumulated at a concrete irrigation diversion structure, and forced high velocity flows toward the left overbank resulting in substantial lateral erosion and the loss of a section of sewer line. Debris dams tended to occur where structures or dense woody vegetation narrowed the

main channel to a width less than the length of debris (typically trees) transported by the flood. Stable reaches with less significant lateral erosion tended to be wide enough to reduce the potential for debris blockage.

Another observed cause of channel change was avulsion of the main channel into the floodplain. This process occurred in areas where flows overtopped the main channel or flanked existing bank vegetation, concentrated in the floodplain, and eroded non-resistant floodplain sediments to form a new channel. This process was particularly effective in floodplain areas with sparse vegetation and areas where floodplain vegetation had been removed, creating zones of low roughness which enabled high velocity, erosive flows to concentrate. Figure 12 and Figure 13 illustrate the avulsive erosion process at two locations along the Santa Clara River. The process of flows flanking the main channel vegetation was observed to be most effective in areas where the flows had a clear pathway back to the main channel. In areas where dense vegetation intercepted and blocked flows from returning to the main channel, the flow energy appears to have dissipated and become less erosive. Where overbank flows were able to reach the main channel via a clear pathway, headcuts often formed at the confluence points. Those headcuts migrated up the overbank flowpaths, further accelerating erosion of the overbank soils.

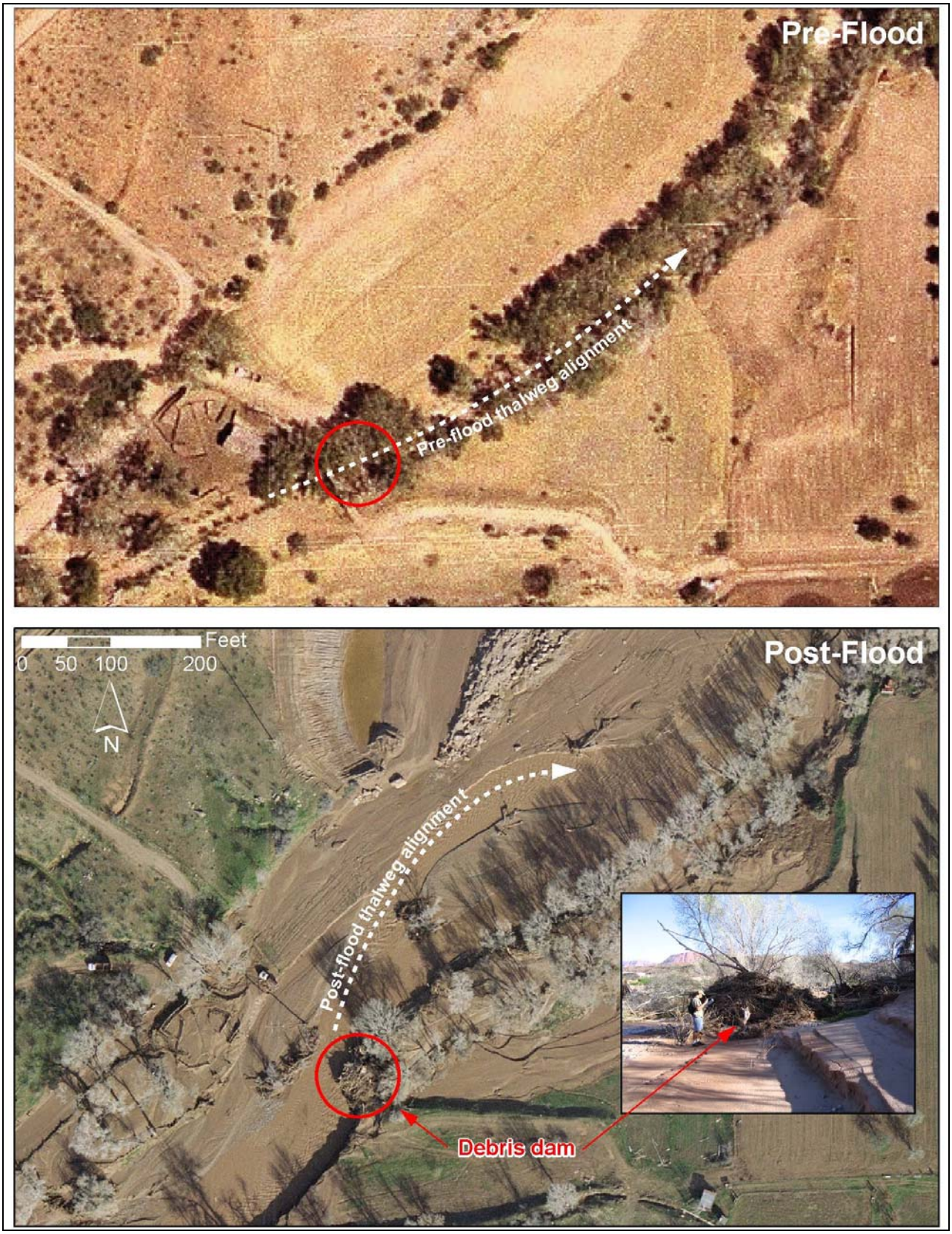


Figure 10 - Avulsion Caused by a Debris Dam on the Santa Clara River

Figure 11 - Significant Lateral Migration and Erosion Caused by a Debris Dam

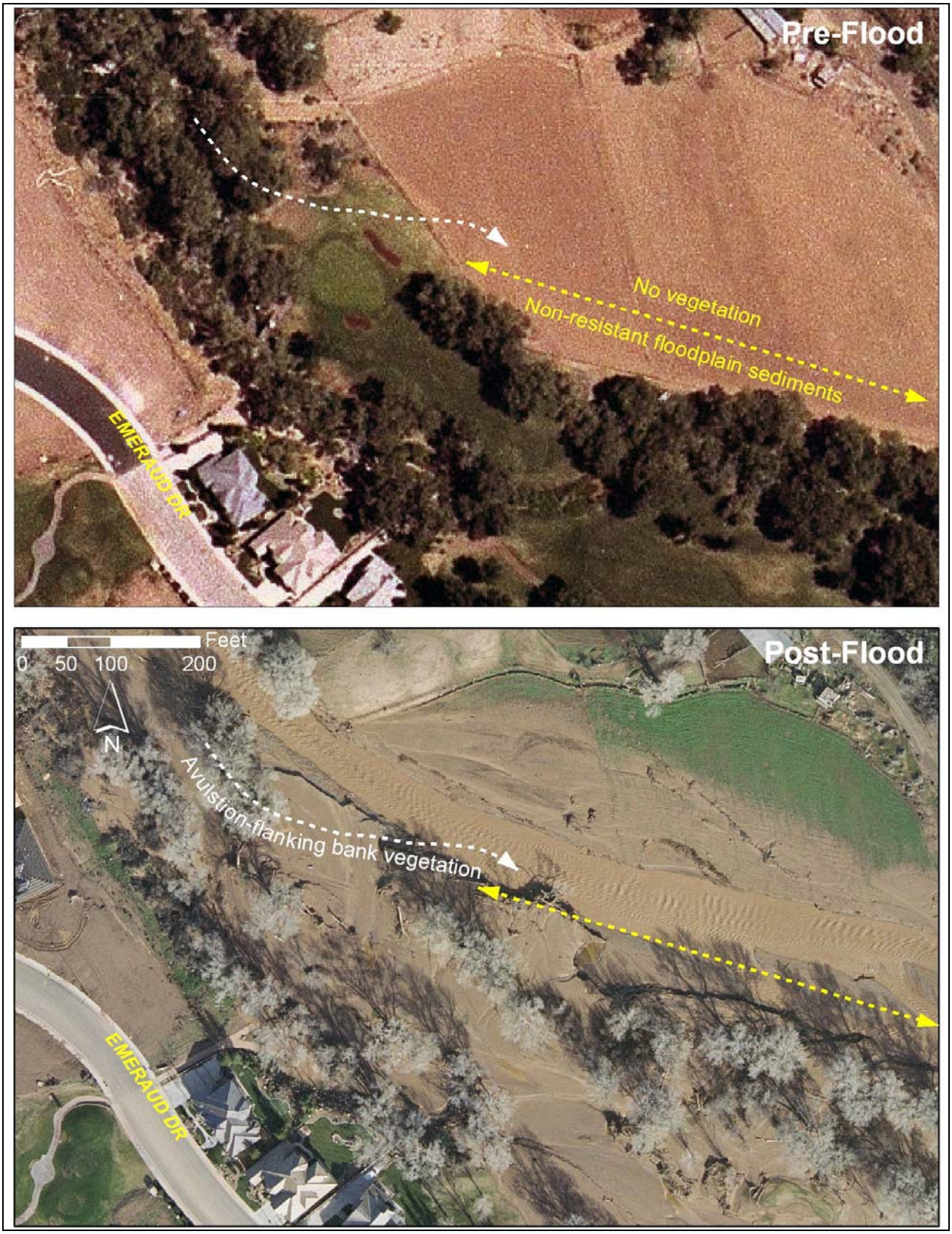


Figure 12 - Example 1 of Channel Avulsion and Erosion of Floodplain Sediments

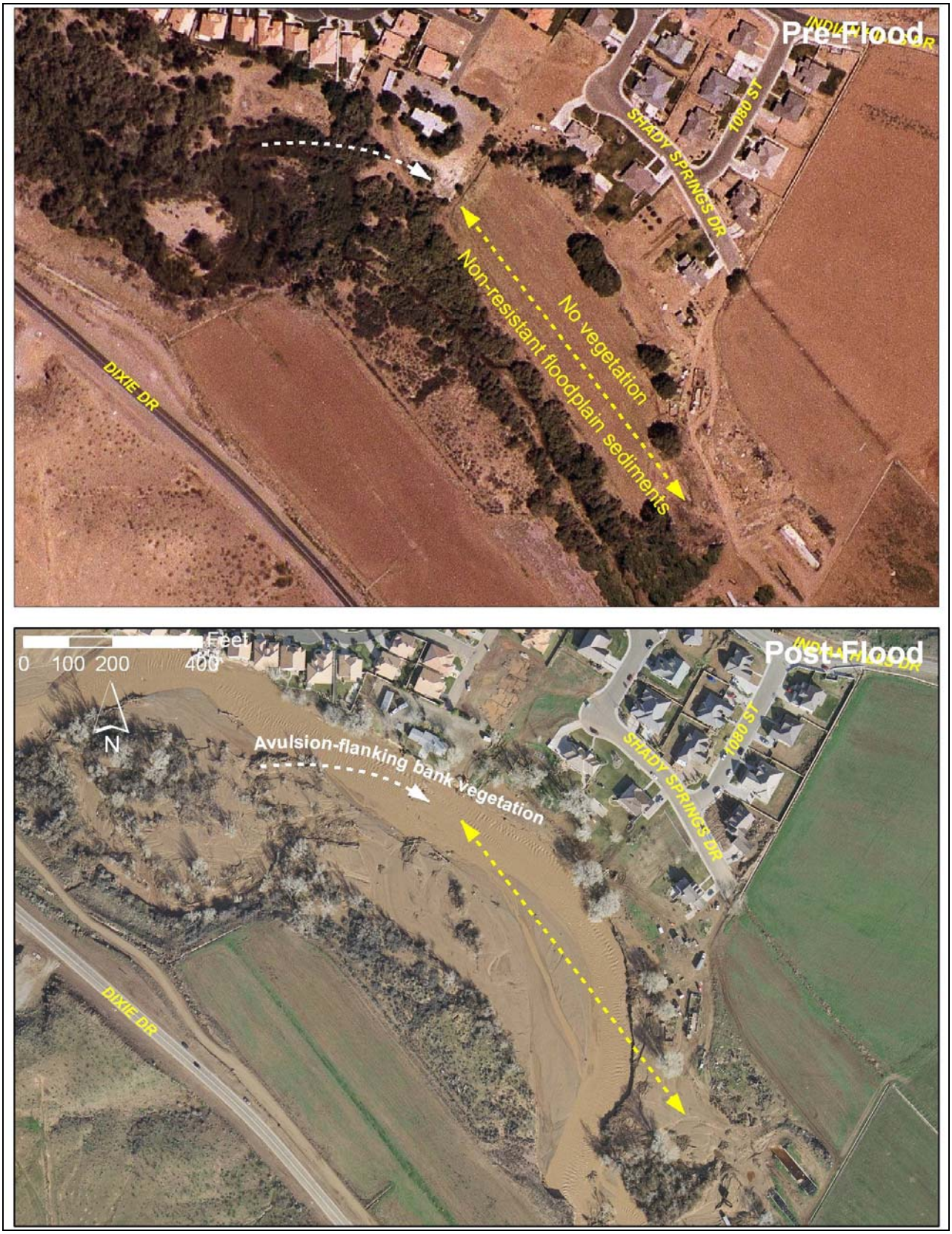


Figure 13 - Example 2 of Channel Avulsion and Erosion of Floodplain Sediments

The most common result of observed channel change in the 2005 flood was simple widening or migration of the low-flow channel banks to accommodate the flood volume. The 1997 study described the bank vegetation as follows:

> *The channel banks in the upper half of the study reach were vegetated with mature cottonwoods and other deciduous trees, with a health understory of brushy and grassy ground cover. The channel banks in recently developed aresa in the lower half of the study reach were poorly vegetated or were unvegetated. Tamarix and grass were the dominant type of bank vegetation in the unstable reaches and were typically perched above the vertical cut banks.*

The bank vegetation was inconsistent in providing adequate erosion protection. In some areas the vegetation seemed to prevent lateral erosion of the banks, while in others it appeared to have been undercut or uprooted during the flood, irrespective of vegetation type. This inconsistency makes predicting bank stability by vegetative measures uncertain. Clearly the pre-flood channel contained insufficient capacity to convey the flood peak, thus a wider conveyance corridor was established by the flood.

Virgin River – Washington County, Utah. The Virgin River within Washington County, Utah experienced changes to both the active channel corridor and floodplain areas during the 2005 flood. However, the changes were smaller in scale compared to those on the Santa Clara River. Also, unlike the Santa Clara, the most severe flood effects occurred inside the 100-year floodplain. Those effects included sediment deposition on the floodplain, vegetation removal, debris accumulation, and lateral migration and widening of the low-flow channel.

The most severe changes in the Virgin River study reach occurred in the vicinity of the Man-of-War Road Bridge. Upstream of the bridge, the pre-flood low-flow channel was characterized by a gradual, wide radius bend with dense vegetation adjacent to the low-flow channel with vegetation density decreasing outward across the left-overbank floodplain. Vegetation patterns in this overbank area indicated the presence of historical overbank flow channels across the surface. During the 2005 flood, overbank flows were able to concentrate in the overbank corridors where vegetation was sparse to nonexistent. This resulted in a near avulsion of the main flow channel and likely contributed to a larger volume of flow in the floodplain potentially resulting in greater amounts of sediment deposition. Figure 14 shows this location. Bank vegetation in this reach appears to have survived the flood and was moderately effective at stabilizing the low flow channel position.

Figure 14 - Virgin River Upstream of Man-of-War Road Bridge

Similar processes of change occurred downstream of Man-of-War bridge in St. George. Prior to the 2005 flood, the vegetation pattern of the right-overbank was characterized by dense thickets of tamarisk with interwoven areas of no vegetation, and remnants of overbank flow channels. During the 2005 flood, overbank flows were able to exploit the low-roughness areas resulting in concentrated, higher velocity flows in the overbanks. Figure 15 shows the resulting overbank channel formation.

Directly across the river from the area described above is the reach of the Virgin River that experienced the significant degree of lateral migration. Approximately 2 acres of pasture land were eroded by the flood. One likely explanation for erosion of the left bank is a flanking of the bank vegetation by overbank flows as occurred in multiple locations along the Santa Clara River. Once the flows were outside the rougher vegetation corridor, the smooth pasture land would have enabled high velocity, high energy flows to concentrate and erode the non-resistant soil. Figure 16 illustrates this potential explanation for the lateral migration in this area.

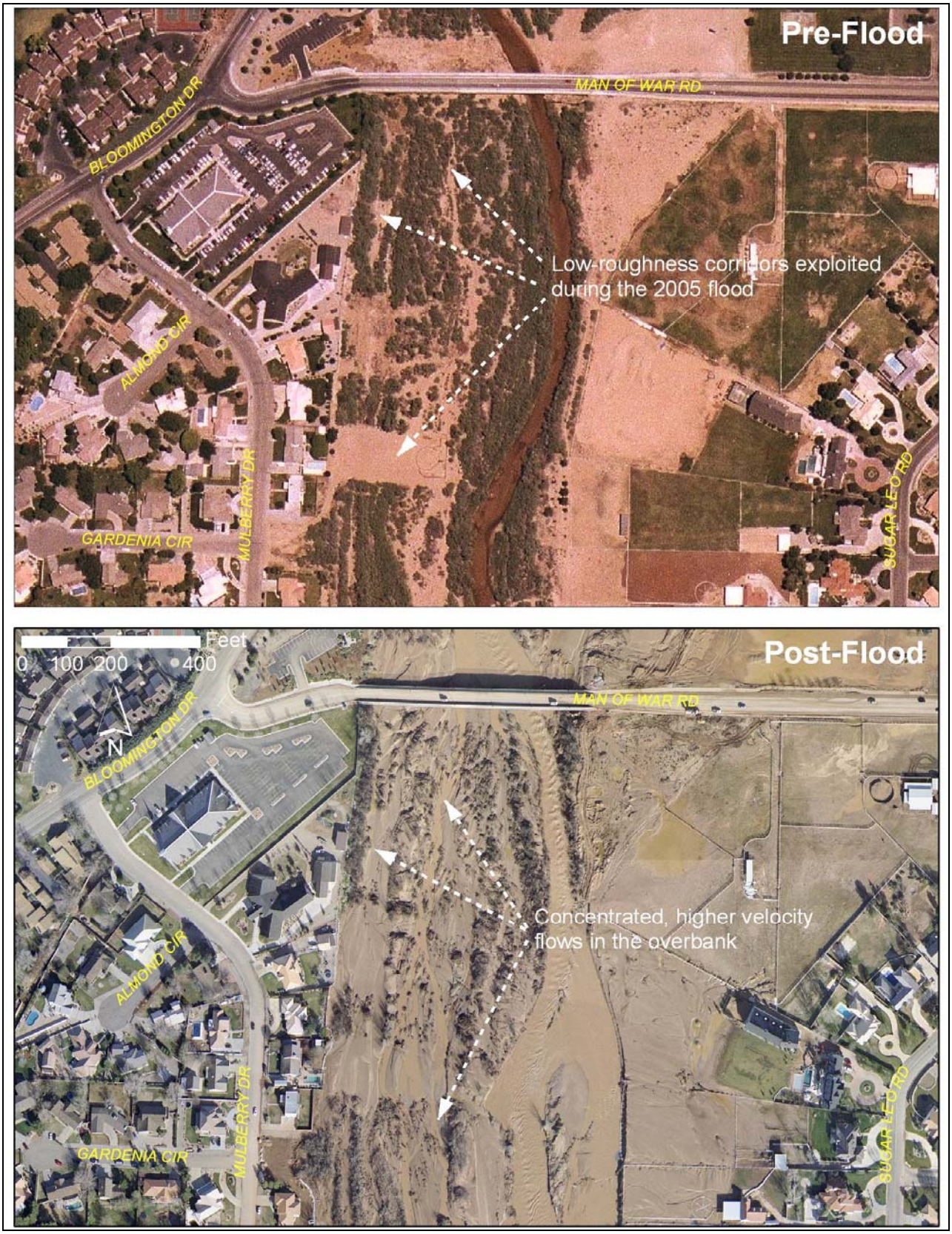


Figure 15 - Virgin River downstream of Man-of-War Road Bridge

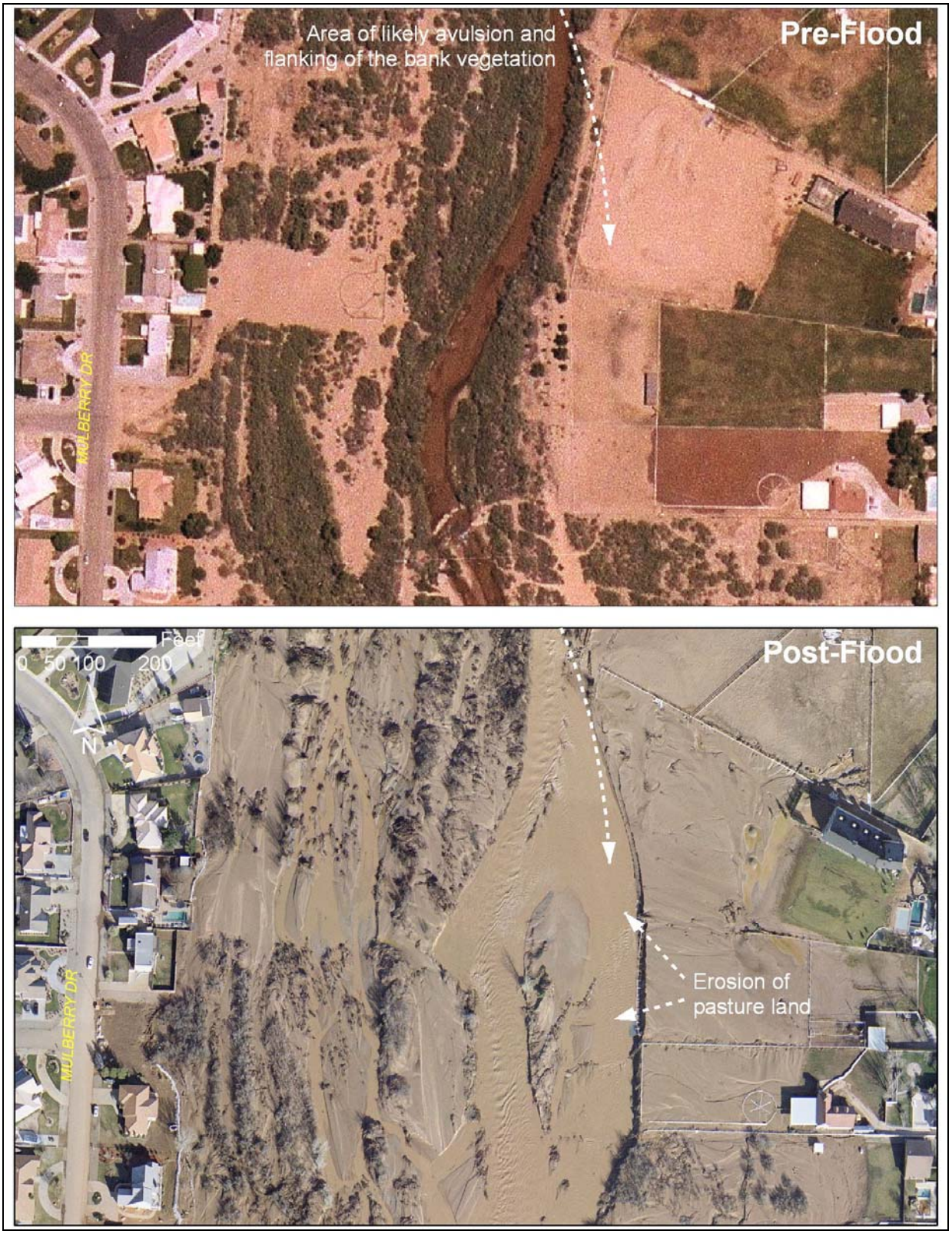


Figure 16 - Lateral migration on the Virgin River downstream of Man-of-War Road Bridge

Virgin River – Clark County, Nevada. Both anecdotal and field data indicated one of the causal mechanisms for abrupt changes in channel bank location of the Virgin River in Nevada was debris blockage of the pre-flood active channel. A debris dam was one factor that caused the main channel to avulse into the right overbank floodplain resulting in the flooding of several homes outside the 100-year regulatory floodplain.

Immediately prior to the 2005 flood, the active channel width of the Virgin River within the immediate vicinity of Mesquite, Nevada was at its narrowest in the period of record. Additionally, the preceding drought years had resulted in encroachment of dense tamarisk into the active channel corridor and an increase in channel sinuosity. As the 2005 flood widened the channel, it accumulated a large load of vegetation debris from bank erosion within the study area as well as upstream. This debris frequently became trapped by remaining bank and channel vegetation, resulting in the formation of dams that created backwater, which raised the water surface elevations and forced flow into the overbank resulting in avulsions. It is believed that debris blockage was a primary cause of the large avulsion that occurred just upstream of the study area resulting in inundation and erosion damage to the homes along Cottonwood Drive and Grayce Drive. Figure 17 shows a pre- and post-flood aerial photo comparison of the Virgin River at the location of the avulsion.

Aerial photo and detailed field analysis of the avulsion channel suggested that once the flows were able to flank the dense tamarisk along the right overbank, the overbank flow path was relatively smooth allowing for high energy flows to concentrate and scour the non-cohesive, erodible, sandy, floodplain soils. The pre-flood floodplain surface in this area was comprised of flat, smooth, and slightly elevated agricultural fields. Between the fields and the main channel, a row of extremely dense tamarisk served as a barrier preventing the avulsive flows from re-entering the main channel. The low-roughness, relatively flat, highly erodible floodplain combined with the dense vegetation barrier allowed the avulsive flows to concentrate and remain perched to form a defined channel.

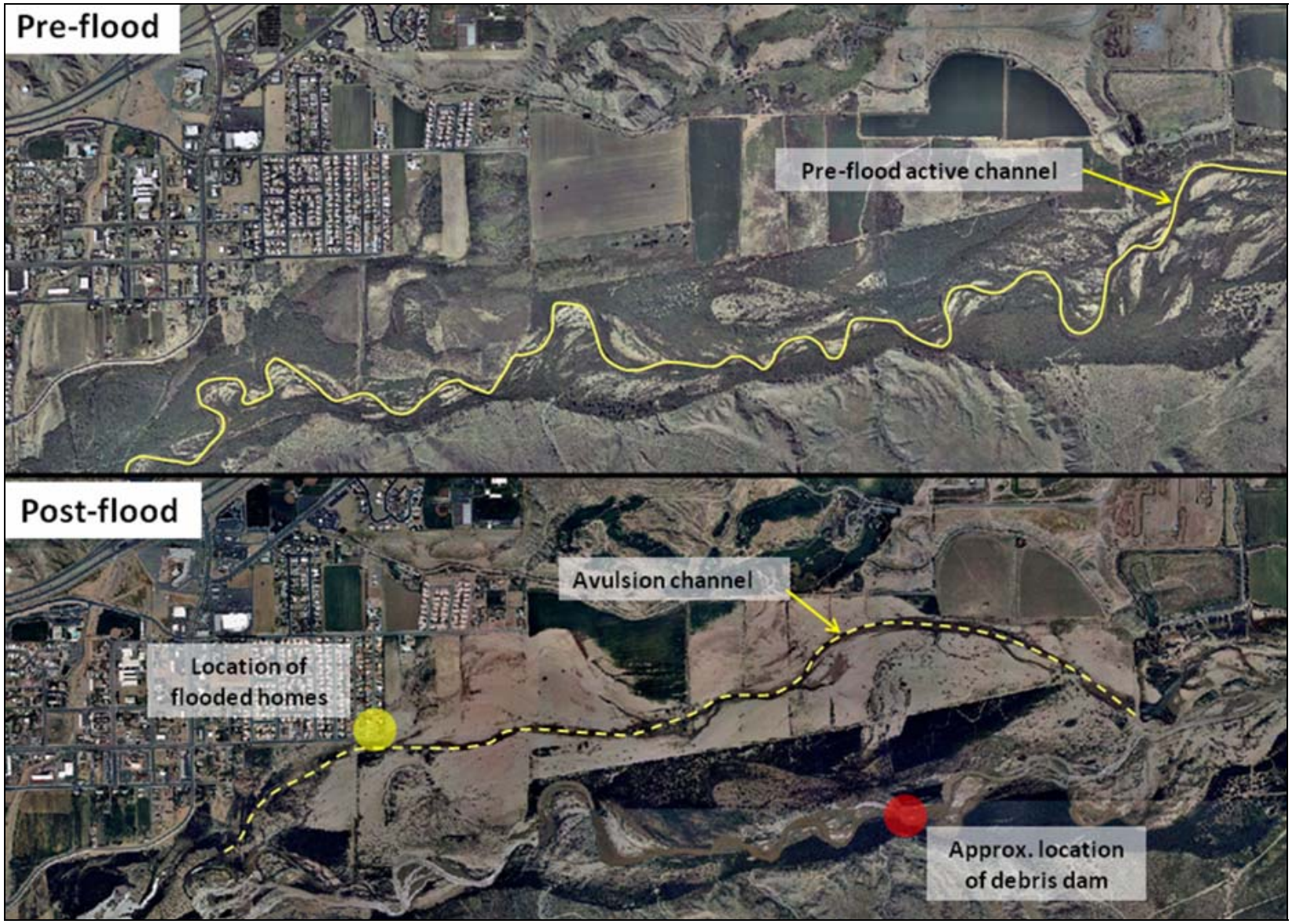


Figure 17 - Virgin River avulsion near Mesquite, Nevada

Solutions. Following the 2005 flood, the Washington County Water Conservancy District (WCWCD) and the cities of St. George, Utah and Santa Clara, Utah initiated a Master Plan study to evaluate and recommend a river management plan for the Virgin River, Santa Clara River, and Ft. Pearce Wash. The study was authored by Natural Channel Design (NCD) and contained the following primary objectives:

- ✓ Minimize property damage from future lateral erosion and flooding
- ✓ Assist private landowners and city governments in managing present land use and future development
- ✓ Provide long-term maintenance guidelines
- ✓ Maintain the natural function
- ✓ Enhance native riparian vegetation and associated wildlife habitats
- ✓ Increase aesthetics and recreation values

The Master Plan assessed the existing condition (post-flood) stability of the streams which included an analysis of the mechanisms of channel change from the 2005 flood, geomorphic assessments of the watercourses, and a hydraulic analysis to develop a baseline condition from which recommendations could be made. A stream stability template was developed for each watercourse which included the following elements:

- ✓ Channel cross-section template
- ✓ Channel alignment
- ✓ Vegetations management strategies
- ✓ Land use recommendations
- ✓ Bank stabilization measures
- ✓ Wetlands and water quality issues
- ✓ Long-term riparian corridor management recommendation

Details on the Master Plan and its role in the Watershed Management Strategy are discussed in detail elsewhere in this report (Sections 7.2.1.4 and 7.2.2.2).

5.3 Urbanization

Urbanization is the transition from a natural landscape to a residential, commercial and/or industrial land use. Changes occurring within a natural watershed that are typically associated with urbanization include: a re-contouring of existing terrain, a thinning of vegetation, soils disturbance, an increase in the percent of impervious area and the construction of drainage and flood control infrastructure. As a result of these changes, likely hydrologic and geomorphic impacts to a watershed include the following:

- ✓ An increase in runoff frequency, magnitude and volume.
- ✓ A decrease in stream base flow.
- ✓ An increase in sediment supply during urban construction, followed by a decrease in sediment supply as urbanization is completed.
- ✓ Changes in watercourse channel morphology.
- ✓ An increase in watercourse organic and inorganic loading.
- ✓ A loss of aquatic habitat and riparian corridors.

An increase in runoff frequency, magnitude and volume is primarily attributed to the increase in percent of impervious area after urbanization has occurred within a watershed. In essence, increasing the impervious area decreases the volume of precipitation that is capable of infiltrating into the soil. Thus, runoff that once soaked into the ground is now conveyed as shallow, overland flow until it is captured by a stream. Amplifying this phenomenon is the construction of drainage and flood control infrastructure, such as storm drains and channels. As runoff is conveyed in a more efficient manner, the frequency, magnitude and volume of flow increases in a shorter time-period. In response to a changing flow regime, the stream channel morphology will begin to evolve. Channel changes could include downcutting, widening, or both, in a repeating sequence.

As urbanization increases runoff, and provides a more efficient conveyance mechanism, heavier loads of organic and inorganic pollutants are often seen within a stream system. For example, as existing ground and vegetation is disturbed during development, the once stable soils are easily eroded and are carried to streams via stormwater and wind. A sediment laden stream is often polluted enough to severely diminish the health of an aquatic habitat. In order to control sediment influx to a stream during construction activity, a Storm Water Pollution Prevention Plan (SWPPP) detailing construction site Best Management Practices (BMPs) is highly recommended. As urbanization stabilizes in an area, the once-available sediment supply quickly diminishes. A stream usually responds to a decrease of available sediment load by removing the available sediment supply from within the channel itself. As the stream attacks the channel bed and banks, the channel will begin to downcut, widen or some combination of the two, until equilibrium is achieved.

Finally, as runoff infiltration into soils decreases, so too does the available groundwater a stream will typically capture as base flow.

The above described impacts to a stream system, which are a direct result of urbanization, typically have an adverse impact on aquatic habitat, riparian corridors, and the overall health of a watercourse.

5.3.1 Encroachment

Urbanization often results in the encroachment of development into a floodplain, floodway and/or erosion hazard zone without an adequate understanding of the stream's tendency and potential to flood and/or laterally migrate. As Charles McHugh of the Arizona Division of Emergency Management stated during the data collection phase of this study, the single biggest problem floodplain managers face is as follows:

> *"The continued encroachment of homes and infrastructure into potential hazard areas. From the emergency management perspective, flood damage is the most costly natural hazard encountered by the state of Arizona. This includes… flooding of homes and businesses, streambank erosion and scour and damage to property and structures. Arizona's population growth challenges effective floodplain management."*

Often encroachment into a floodplain is thought of in terms of a regulatory floodway. The regulatory floodway is the portion of watercourse and adjacent land areas that must be reserved (not encroached upon) in order to convey the base flood (typically the 100-year peak discharge) without cumulatively increasing the water surface elevation more than a designated height (typically 12 inches). The floodway is where the water is likely to be deepest and fastest; and therefore, should be free of obstruction. It is important to note that the floodplain and floodway limits depicted on a regulatory map show an approximate area inundated during conveyance of the base flood peak discharge, and that these limits do not reflect an area safe from all natural hazards, such as channel migration and/or bank erosion. This fact was brought to light during the January 2005 flooding on the Virgin River where extensive channel lateral migration and bank erosion resulted in millions of dollars of property loss. Additional discussion regarding Mitigation Actions to protect against encroachment is provided in Section 7.2.1.4.

5.4 Invasive Plant Impacts

According to the U. S. Department of Agriculture (USDA, 2007a),

> *"Invasive plants are introduced species that can thrive in areas beyond their natural range of dispersal. These plants are characteristically adaptable, aggressive, and have a high reproductive capacity. Their vigor combined with a lack of natural enemies often leads to outbreak populations."*

Two common invasive plant species found within the Virgin River watershed include tamarisk and cheat grass.

5.4.1 Tamarisk

Tamarisk is a type of invasive shrub-tree that was first introduced to the southwest (in the 1850's) as ornamental vegetation from Asia, but was also commonly used for erosion control and windbreaks. However, this species quickly invaded riparian areas throughout the southwest, including areas within the Virgin River watershed. The U.S. Department of Agriculture claims that within Nevada, California, Arizona, Utah and Colorado, up to 90 percent of riparian areas and wetlands are impacted by tamarisk (USDA, 2007b).

According to the National Institute of Invasive Species Science,

> *Mature tamarisk trees can produce millions of pollen-size seeds. They disperse through the wind and down watersheds. Seeds can germinate while floating and establish themselves on wet banks within 2 weeks. Newly formed sand banks are particularly susceptible. Plants can be 10 centimeters tall in the first 2 months and can grow to 12 meters tall over a 50-year life. The taproot can reach 30 meters down with a root spread of up to 50 meters. Trees may reproduce in the first year but more typically in the second. Adventitious roots can produce new trees when buried.*

Within the Virgin River watershed, tamarisk occurrences range from vast monotypic stands to individual trees interspersed within native vegetation. However, when tamarisk dominates floodplain vegetation, the normal function of a watercourse is impeded. Stream channels typically become restricted or choked, resulting in large volumes of flood flow being forced out of the primary channel, increasing the potential for property damage, bank erosion and/or channel avulsion. Similarly, tamarisk overgrowth increases channel and floodplain roughness, which will slow flow velocity and increase flood depth. As a result, channel aggradation may become a trend, which will decrease conveyance capacity and force large volumes of flow onto the overbank area. Figure 17 shows an example of channel avulsion that occurred during the January 2005 flooding due to tamarisk overgrowth within the Virgin River, just upstream of Mesquite, NV.

Tamarisk thickets are areas of increased fire hazard. Due to the fast growth of tamarisk, abundant dead leaves and branches make for ample fuels for wildfire. After the occurrence of a wildfire, tamarisk again grow quickly while native riparian trees and shrubs are generally overwhelmed and tend not to thrive (Barrows, 2007). Several severe fires have been documented within thickets at various locations along the Virgin River (see Section 5.1). These fires are of great concern as they may spread to developed areas adjacent to the riparian corridor.

Finally, tamarisk tissue accumulates salt (hence the alias saltcedar), which is later released into the soil. The resulting salt laden soil is unsuitable for growth of many native species, which then tend to die out.

5.4.2 Cheat Grass

Cheat grass is native to Europe, the northern rim of Africa, and southwestern Asia. It was introduced to the southwest in the 1800's accidentally as part of contaminated seed. It often establishes itself in disturbed areas and can be found on rangelands, pastures, prairies, fields, waste areas, eroded sites, and road sides. Once established, cheat grass can remain a dominant species for many years altering the native regime (USFS, 2007).

Like tamarisk, cheat grass is another invasive species of concern within the Virgin River watershed. The primary concern is the high susceptibility to fire for areas containing thick cheat grass land cover. Cheat grass grows during the winter and dies by the end of July, an inverse of the growing cycle of native grass species. By dying during peak wildfire season, cheat grass facilitates fire ignition and travel. Wildfire susceptibility in the watershed is directly related to changes in the rainfall/ runoff characteristics of the basin with consequent negative impacts to floodplains.

5.5 Flood Response Planning

During the 2005 flood events in the Virgin River basin, emergency response was varied. Major roadway crossings in the river corridors were destroyed or damaged thereby limiting options for emergency response. Little access was available along the river corridor to allow placement of emergency bank protection. Stakeholders reported spotty, if any, communication with emergency responders upstream and downstream in the basin. These experiences directly speak to the need for flood response planning for the Virgin River watershed.

A flood response plan must have a foundation of good scientific application of meteorological, hydrological, and engineering principles and a thorough understanding of the needs and capabilities of the emergency response agencies. An effective flood response plan takes into account the needs of and utility to the end user of that plan, namely the local emergency response community. A flood response plan that is too complex or too technical is not likely to be well understood or effectively used by emergency response personnel under the duress of an imminent flood emergency. A flood response plan that is interactive and easily understood enhances its value and utility to the end user.

The components of an effective flood response plan include the following:

- ✓ Flood Vulnerability
  - *Alert Levels* – Identify increasing levels of alert and associated risks with changing flood conditions
  - *Flood Vulnerability Assessment* – Assess at-risk structures and infrastructure
  - *Lead Time* – Evaluate the amount of lead time, if any, available to emergency responders to take specific actions

- ✓ Flood Detection
  - *Prediction* – Identify predictive tools (i.e., satellite, radar products)
  - *Detection Gage Network* – Identify detective tools (i.e., ALERT rain, weather, stream gage data)
  - *Flood Detection Criteria* - Set thresholds for triggering alert levels
- ✓ Information Dissemination
  - *NWS Messages* – Flood Watches, Flood Warnings, Sever Storms, Urban Flooding Alerts
  - *Local Flood Alert Messages* – Basin-specific messages
  - *Communication Flowchart* – Diagram of paths and means of emergency data and voice communication
- ✓ Flood Warning Message Suite – Standard messages for dissemination to agencies and the public linked to specific actions
- ✓ Action Plans – Specific action protocols for each agency at each alert level
- ✓ Implementation – Training, exercises, updates, follow-up activities
- ✓ Limitations – Limitations of modeling and detection network operation

6.0 FLOODPLAIN MANAGEMENT IN ACTION: JANUARY 2005 FLOODS

6.1 Background

Substantial regional flooding occurred throughout the Virgin River Watershed from December 29, 2004 through mid-2005. Intense rainfall caused local flooding in the southern watershed while rain-on-snow events created prolonged flooding in the upper and middle watershed.

USGS estimates of the flood magnitudes at gaging locations during the initial events have been summarized in a document titled *Flood in Virgin River basin, Southwestern Utah, January 9-11, 2005*. While the flooding was regional in scale, this document indicates flood magnitudes were generally below that of the base floods.

In spite of the magnitude of the peak flow, flows were prolonged and channel migration and avulsion developed. Debris and vegetation blockage of channels and at structures forced channel movement.

6.2 Flood Elevations

Traditional, FEMA-accepted floodplain analysis is performed using rigid-boundary one-dimensional modeling. Base flood elevations are based upon the evaluations of channel roughness and discharges at the time of the study. During flow events, these parameters can change substantially.

Dynamic changes in channel slope, aggradation and degradation, are not typically accounted for by floodplain analyses. In Mesquite, Nevada, a discharge of approximately 100-year magnitude generated a water surface 4 feet greater than the base flood elevation. In St. George, Utah, a flow of 25-year magnitude reached the base flood elevation. The inability of conventional floodplain modeling to represent event-based channel aggradation within the watershed is significant for the management of development within floodplains.

Base flood elevations and discharges also influence bridge design and can contribute to bridge failure. While channel trends such as aggradation and degradation are typically reviewed as components of long-term channel grade, the 2005 events have shown they are relevant on an event-based scale as well.

Vegetation growth in channels may also exacerbate flooding. Vegetative debris and choked channels were identified as worsening flooding and erosion problems. As mentioned previously, flood studies rely upon “snapshot” views of channel vegetation and do not account for progressive conveyance reduction due to vegetative encroachment, particularly for fast growing invasives.

6.3 Lateral Migration

In Washington County, Utah, the majority of damage from the 2005 events was due to lateral channel erosion rather than inundation. Prior to the events, erosion hazard zone studies had been performed along the Santa Clara River and the Virgin River. Few homes were damaged beyond the erosion hazard zone boundaries, while most homes damaged within the boundaries were elevated above the base flood elevation. No homes built since the erosion hazard zone areas were delineated were damaged. While homes were still destroyed, the ability to define probable lateral migration zones was demonstrated. Widespread application of erosion hazard zone development limitations will potentially limit the magnitude of future lateral migration damage.

Channel avulsion is another form of lateral channel migration. Unlike erosive migration, which essentially describes the gradual lateral movement of a channel, avulsion describes the radical realignment of a channel. The images below illustrate channel avulsion in the vicinity of Mesquite, Nevada following the 2005 events.

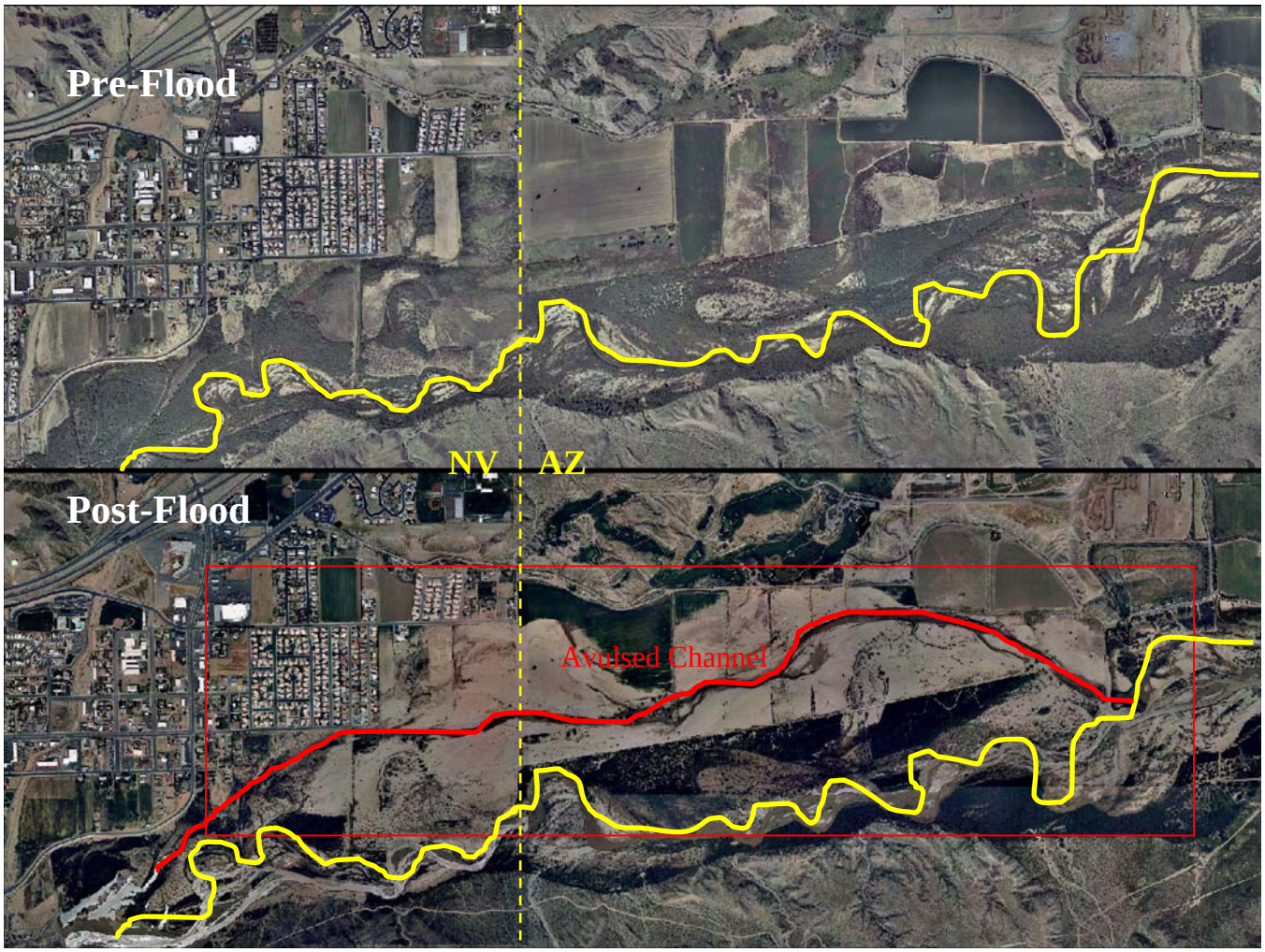


Figure 18 - Arizona Nevada Border Pre and Post 2005 Flooding

6.4 Multi-jurisdictional Issues

Figure 18 highlights the need for multi-jurisdictional solutions. While the channel avulsion occurred in Arizona, the impacts were experienced in Nevada. Although not necessarily the case for the above illustration, differences in floodplain management can translate to downstream communities and property. Jurisdictional boundaries found within the Virgin River watershed are provided in Appendix A.

While aid was available from adjacent communities and agencies during the flooding, no broadly-coordinated, multi-jurisdictional flood response efforts were made. Washington County received approximately $66 million for Emergency Watershed Protection (EWP), while the state of Arizona received approximately $3 million and Nevada received no EWP funds.

Formal communication plans had not been developed. Regionally, stakeholders indicated that communication was adequate, but little or no broader communication efforts were made (i.e. inter-state and inter-community). Some stakeholders indicated State-Federal communication was effective, but communication between local governments was not.

6.5 Flood Response Planning

During the 2005 events, multiple bridges were destroyed or damaged in Washington County. In the vicinity of St. George, emergency response was forced to use a single bridge due to failures of other access points. Additionally, little access was available along the river corridor to allow placement of emergency bank protection.

Response action elsewhere was varied. In Nevada, some emergency action was taken in violation of federal regulations. "Emergency" action was taken after the initial hazard had abated, but insufficient information was available to show the hazard had passed.

6.6 Flood Forecasting

Little data is available within the watershed to facilitate flood forecasting. Flood forecasting may be based upon hydrometeorological data or upstream stream flow data. Reliable hydrometeorological flood forecasting requires precipitation, land use, and topographic data representative of an area to estimate the runoff-excess. Streamflow flood forecasting requires sufficient gaging stations to determine the likely occurrence of a downstream flooding event. No active, real-time USGS precipitation gages are present in the watershed.

Both methods of flood forecasting require upstream data collection. Data collection is most often accomplished through the use of precipitation or stage gages to record rainfall and streamflow, respectively. Beaver Dam Wash is an example of a major tributary to the Virgin River with minimal active gaging.

One active stream gage is present on upper Beaver Dam Wash near Enterprise, Utah. The active gage is located near the headwaters (Enterprise itself is not within the Virgin River watershed). In 2005, significant damage occurred in the communities of Motoqua, Utah and Beaver Dam, Arizona, which are located 16.1 and 49.5 miles downstream of the gage with a consequent 221% and 897% increase in the watershed area, respectively. Contributing areas and river miles are shown in Table 3 below.

Table 3 - Contributing Area and River Mileage Along Beaver Dam Wash

ID	Contributing Area (sq mi)	River Mile (mi)
USGS Gage #09413900	58	49.5
Motoqua, UT	186	33.5
Littlefield, AZ	578	0

For these communities, insufficient information was available to provide meaningful flood warning/forecasting during the 2005 event.

Minimal precipitation gaging is present in the watershed. Mohave and Clark County operate ALERT stations, but few are within the Virgin River watershed. Exhibit A-1 shows the active precipitation and stream gaging network in the watershed. Currently, no single repository for precipitation data exists for the watershed; precipitation data is collected and distributed individually by each county. Stream stage/discharge data is collected and distributed by the USGS through the National Water Information System (NWIS).

Additionally, the National Weather Service (NWS) Colorado Basin River Forecast Center (CBRFC) produces river, flood and water supply forecasts for the entire Colorado Basin and Great Basin, including the Virgin River watershed. The CBRFC provides river forecasts and technical support to local Weather Forecast Offices (WFO). The CBRFC distributes much of its products and services through an interactive web page located at www.cbrfc.noaa.gov. In turn, WFOs prepare Flood Watches, Flood and Flash Flood Warnings and disseminate the products to local emergency managers, media, and the public via standard communication means such as NOAA weather radio and other media outlets. In general, experience indicates that the macroscale of these forecast products limits their relevancy in terms of specificity and timing at the local scale during flood events.

Land use and ground cover information are also of importance for flood forecasting. Within the Virgin River watershed, wildfires are a major influence on ground cover and soil characteristics. No centralized repository of information regarding fire data is available to the public or actively used for the purpose of flood forecasting. Exhibit B-1 shows the extents of fires in recent history.

6.7 NRCS-EWP Bank Protection

In response to flooding, the Natural Resources Conservation Service Emergency Watershed Protection Program (EWP) was activated by Washington County. Approximately $66 million dollars was federally appropriated for emergency watershed protection in southern Utah. EWP funds were spent on riprap bank protection and plantings along the Upper Virgin River, Santa Clara River, Beaver Dam Wash, and Shoal Creek (not in the Virgin River Watershed).

By its nature, the EWP bank protection is a temporary solution for channel instability. EWP funding is a single-year appropriation and does not include a perennial stipend or maintenance component. The primary material used in the bank protection, stone riprap, is typically used as a "flexible" material capable of shifting to conform to changes in channel morphology and depth. Once the material has shifted or launched into a scoured channel, no dedicated funding exists to restore the bank protection to its originally constructed geometry. Following flow events in which the protection launches, the bank protection must be maintained or the current level of lateral migration protection will diminish.

Since its construction, the EWP bank protection has experienced generally low flows. Bank protection was accomplished primarily through the use of two types of placement. The "layback" placement follows typical riprap bank protection design and entailed the placement of a layer of riprap protection along an existing bank for a constructed height of 13 feet. The "rockwall" section consists of a self-supporting mass of stone 11-13 feet tall and 28-33 feet wide at the base. A median stone diameter of 30 inches was specified for both types of bank protection.

A relatively large amount of bank protection (rockwall) was placed in the Town of Gunlock along the Santa Clara River. In early August 2007, a local convective storm burst caused local flooding on a tributary to the Santa Clara River. At Gunlock, the magnitude of this discharge is estimated to be 8,840 cfs. By comparison, the peak discharge during 2005 was 5,200 cfs. Substantial scour occurred at the county bridge south of Gunlock as seen in Figure 19. Additionally, inundation was reported for three homes behind the NRCS bank protection (Winslow, 2007).

Figure 19 - Scour at County Bridge South of Gunlock Following August, 2007 Event

Secondary effects of the protection have been observed. Notably, the stone placement impacts the lateral alignment of rivers. In places, bank protection is present on both sides of the channel without sufficient conveyance area for the 100-year event. Additionally, bank protection was not designed to protect from the 100-year event. During an event of greater magnitude than the 2005 events, overtopping of the bank protection may cause avulsive or erosive action beyond the bank protection; secondary channel formation was observed behind the bank protection during the August 2007 event in Gunlock.

Erosion hazard zones studied after the placement of the bank protection account for its presence; however, the bank protection does not fully mitigate the erosion hazard. This results in placement of the erosion hazard zone beyond bank protection boundaries.

Exhibit C-1 shows the best available information of the location of NRCS EWP bank protection. Figure 20 shows the typical cross section for the “rockwall.”

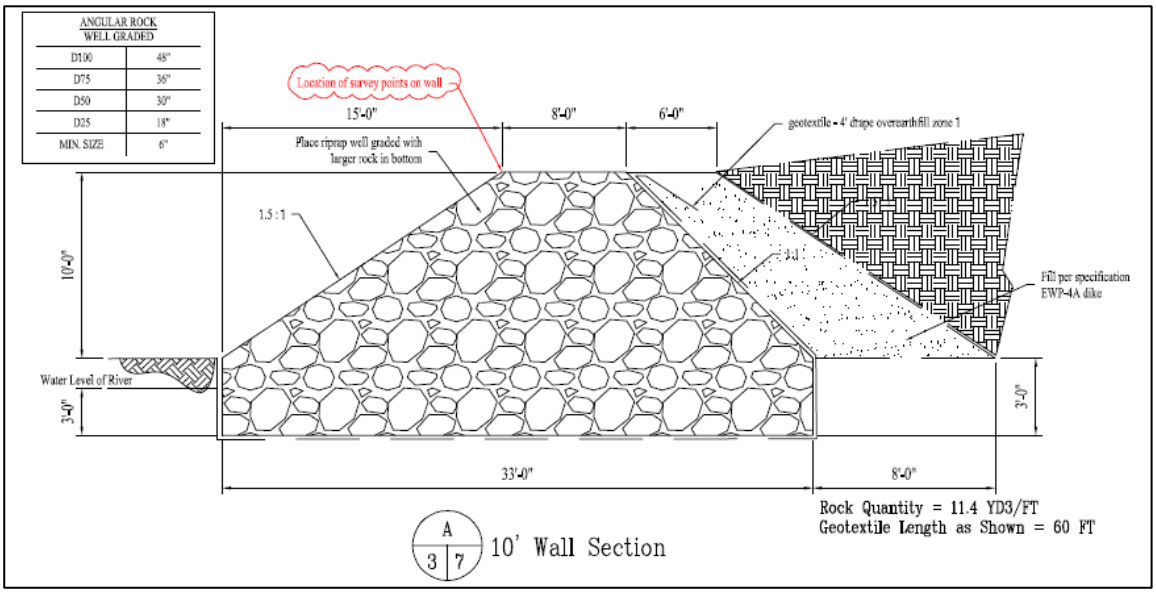


Figure 20 - EWP "Rockwall "

7.0 VIRGIN RIVER FLOODPLAIN MANAGEMENT STRATEGY

The strategic goals recommended below are based on stakeholder input collected during the initial phase of this project. Strategic goals fall under two primary categories: Improved Communication and Improved Floodplain Management. The recommended Mitigation Action items have been identified within each category to provide floodplain administrators, regulators, agencies, municipalities and engineers a basis for floodplain management decision making within the Virgin River watershed. Refer to Figure 4 for a diagrammatic representation of the Floodplain Management Strategy. It is worth noting that the recommended Mitigation Action items discussed below are likely to be more successful if they are implemented seamlessly throughout the watershed, which requires cooperation and communication between local, county, state and Federal agencies.

7.1 Strategic Goal A: Improved Communication

Effective communication is a key element of successful floodplain management. A common theme in the stakeholder meetings and interviews was the need for communication tools for both non-emergency and emergency situations. Several information resources are recommended as part of the VRFPMS to improve inter- and intra-agency communication, to inform decision makers, and to educate the general public.

7.1.1 Non-Emergency Communication

The extent and magnitude of future flood damage can be significantly reduced if Floodplain Administrators, regulating agency personnel, engineers and the public are better informed and educated about flood hazards and flood mitigation strategies. In order to adequately attempt to communicate this information, the following Mitigation Actions items for the development of information resources are recommended:

- ✓ **Mitigation Action 1 - Handbook.** Development of a *Floodplain Management Handboook* for use by both the technical and non-technical communities.

- ✓ **Mitigation Action 2 – Public Information Brochure.** Development of a *Flood Hazard Brochure* for communication with the public.

- ✓ **Mitigation Action 3 – Contacts Database.** Development of a contacts database formatted to facilitate ease of use by stakeholders in both emergency and non-emergency situations.

- ✓ **Mitigation Action 5 – GIS Database.** Development of a GIS database to create a central clearinghouse of spatial data and other related products.

- ✓ **Mitigation Action 14 – Steering Committee.** Establishment of a Steering Committee to provide a forum for oversight in the implementation of the VRFPMS.

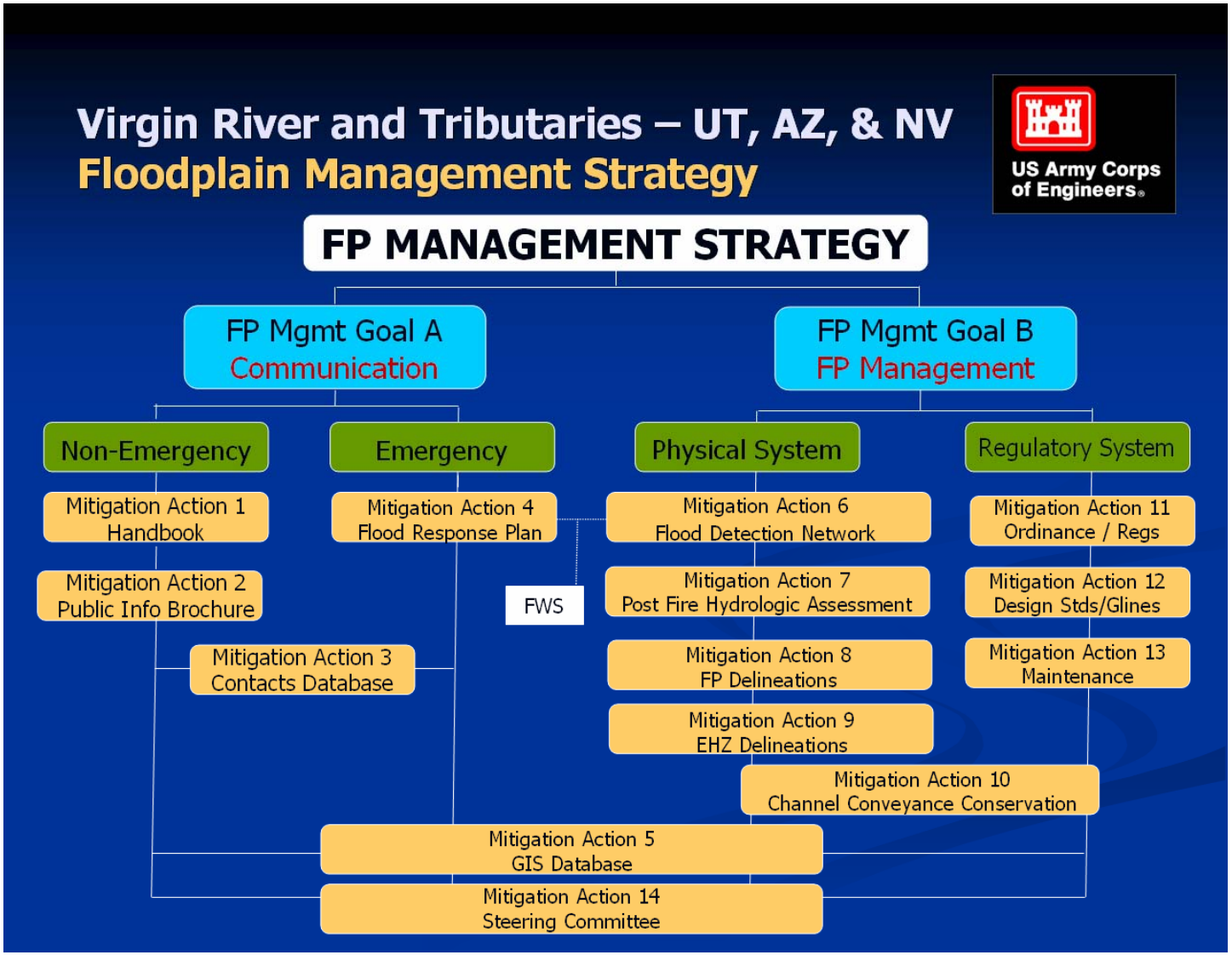


Figure 21 - Floodplain Management Strategy

7.1.1.1 Mitigation Action 1 – Floodplain Management Handbook

Although several floodplain management publications are available through various agencies (see Table 2), it is recommended that information within these publications be filtered, with the most relevant portions being compiled and published in a *Floodplain Management Handbook* that is applicable for use within the Virgin River watershed. The intent of the *Handbook* should be to provide both the technical and non-technical communities a tool for making educated, practical decisions in regards to flood control, erosion control and water quality protection. The *Handbook* also will serve to provide information continuity in cases of personnel turnovers.

The technical community typically consists of floodplain managers and engineers, while the non-technical community typically consists of elected officials, property owners, land users, realtors, and money lenders. Important information and data used by both communities, and recommended for publication within the *Handbook*, includes the following:

- ✓ Flood and Erosion Hazards/ Risks
- ✓ Floodplain Management Strategy – Goals and Mitigation Actions
- ✓ Implementation Plan
  - Priorities
  - Benefits of implementing the plan
  - Risks of not implementing the plan
  - Funding options
- ✓ Contacts Database
- ✓ Design Standards, Guidelines and Publications
- ✓ Floodplain, Floodway and EHZ Ordinances/ Regulations

7.1.1.2 Mitigation Action 2 – Public Information Brochure

Readily available brochures that educates the general public about flood control, erosion control, and water quality management issues is a cost effective, proactive approach to floodplain management. A presentation/video could be an alternate format depending upon the transmission media selected. Much like FEMA's pre-hazard mitigation program, hazard prevention efforts represent a cost savings versus post-hazard efforts.

Suggested topics to be discussed in the brochure include the following:

- ✓ Flood and Erosion Hazards/Risks
- ✓ Fire impacts on hydrology
- ✓ Water quality issues
- ✓ Strategies for single family home owners to implement to help protect against flood related hazards and a listing of free publications that provide additional information
- ✓ Community's Flood Response Plan

- ✓ Flood warning information such as ALERT stations, website and emergency responder's contact information

7.1.1.3 Mitigation Action 3 - Contact Database

In order to achieve the strategic goal of improved communication, mitigation actions associated with both emergency and non-emergency scenarios need to be addressed. In addition, it is essential that both intra- and inter-communication take place within and between local, county, state and Federal agencies. To that end, a communication database (see Appendix E) has been developed for use as a basic floodplain management tool. In order to facilitate the use of the contact database by stakeholders in both non-emergency and emergency situations, the database was sorted by alphabetical order, agency name/ type, state, and in the upstream/downstream direction along the Virgin River. The contacts database needs to be easily accessible and updatable. The communication database is also provided electronically on DVD, located in Appendix H. The communication database includes tentative representatives associated with each Mitigation Action discussed in the *Virgin River Watershed and Tributaries Floodplain Management Strategy Report.*

7.1.1.4 Mitigation Action 5 – GIS Database

- ✓ Spatial information resource
- ✓ Aerial photos
- ✓ Multiple shapefiles
  - Jurisdictional boundaries
  - Watercourses/ Roadways/ Landmark features/ Town names
  - FEMA Regulatory floodplains/ floodways
  - Erosion hazard zones
  - Rain/ stream gage locations
  - Virgin River tributary subwatersheds
  - Man-made flood control structures
- ✓ Links to information resources
  - Handbook (Mitigation Action 1)
  - Public Information Brochure (Mitigation Action 2)
  - Contacts Database (Mitigation Action 3)
  - Ordinances/ Regulations (Mitigation Action 11)
  - Design Standards/ Guidelines (Mitigation Action 12)
- ✓ Links to work products
  - Virgin River Watershed Analysis Report (Needs Analysis and Strategy)
  - Virgin River Floodplain Management Strategy Report
  - Other Studies/ Reports
  - Communication Bulletin Board

A listing of available Virgin River watershed GIS data types and sources is provided in Appendix F. In addition, various GIS shape files are provided electronically on the DVD located in Appendix H.

7.1.1.5 Mitigation Action 14 – Steering Committee

It is recommended that a steering committee consisting of stakeholder representatives be convened on a regularly recurring basis for the purpose of maintaining effective communication and forward momentum in the implementation of the VRFPMS. In non-emergency situations, it is envisioned that such a group would seek programmatic and funding assistance for the Mitigation Actions, monitor status/ progress of the VRFPMS Implementation Plan, and establish/ modify priorities as appropriate. The establishment of inter-agency working relationships resulting from the steering committee's mission will also facilitate better communication during emergency situations benefiting flood response within the Virgin River watershed.

Stakeholders in the December 13, 2007 floodplain management meeting recommended the following criteria for a steering committee. Establishment of such could provide the necessary framework for ongoing coordination and collaboration, and most importantly would be necessary to facilitate organization and continued watershed wide efforts.

- Tri state oriented.
- Not an oversight group.
- The committee May serve as a funding/organizing mechanism
- Membership could include technical and administrative levels
- The Washington County fire management committee is a possible model.
- Participants:
    - Local representatives, County representatives, NRCS, BLM, USACE, USGS, NPS, USFWS, Tribes, States (agencies identified).
    - Elected Officials: County Commissioners, Congressional Staffers.

Important aspects to consider in the committee's makeup include:

- Authority to make decisions
- Authority to commit resources
- Scale
- Involvement of elected officials

7.1.2 Emergency Communication

In order to help prevent loss of life, increase public safety, and ensure prompt effective response during flood emergency situations, the development of a flood warning system is recommended. Basic elements of a flood warning system include the following:

- ✓ Early flood detection.
- ✓ Assessment of potential flood conditions.
- ✓ Dissemination of information.
- ✓ Implementation of Flood Response Plan.

7.1.2.1 Mitigation Action 4 – Flood Response Plan

Successful execution of a Flood Response Plan is dependent on the preparation effort taken prior to an emergency. An adequate preparation effort entails the following:

- ✓ Up-front commitment of resources for continuing maintenance and modification.
- ✓ Continual updating of Flood Response Plan to reflect land use and population changes occurring within the watershed.
- ✓ Ongoing training of emergency respondents and decision makers. This includes mock exercises or simulations.

Early Flood Detection. Real-time flood data can help reduce injuries, prevent death and decrease property damage (See Section 7.1.1.2). For these reasons it is recommended that communities and agencies operating within the Virgin River watershed establish and maintain a seamless flood detection network. The network should consist of ALERT stations (rain, weather, and stream gage stations) located at strategic locations along the Virgin River and its significant tributaries. Given the importance of sharing real time flood information, data collected by the network should be stored in a central system that is accessible by all. In addition, a secondary redundant system should collect and store network data, which can then be used as a backup to the primary storage system. It is understood that several ALERT stations are currently in use throughout the watershed; these stations can serve as the foundation of the network. It is recommended that all existing and future ALERT stations be integrated into one overall flood detection network that can collect, store and disseminate information to all interested parties throughout the Virgin River watershed. See Exhibit A-1 for a map of ALERT station locations within the Virgin River basin.

Potential Flood Condition Assessment. As real time flood information is collected, it is necessary to assess anticipated flood conditions and potential flood hazards. This assessment will help emergency responders to prioritize areas of highest risk, which are typically areas that may be below the flood level. Assessment of potential flooding will typically be based on information collected by an ALERT station network. With this collected data, the following flood conditions should be estimated:

- ✓ Estimation of flood wave travel time to help ensure sufficient lead time for emergency responders to react.
- ✓ Estimation of rate of stage increase and probable maximum stage. This should also include discharge and flow velocity estimates.

In addition, monitoring of existing flood control infrastructure, such as dikes, levees, dams and drainage systems is recommended as part of the potential flood hazard assessment.

Information Dissemination. Collection of real time flood information, and the assessment of probable flood conditions, is an academic endeavor unless this information

is disseminated to emergency responders and decision makers. For dissemination of this information, the following actions are recommended:

- ✓ Ensure the National Weather Service has timely flood condition information for broadcast to the general public.

- ✓ Ensure local and county agencies are equipped to disseminate flood condition information to the public during and emergency situation. This may be accomplished through a dedicated web site, dedicated phone number for messaging, and/or television and radio broadcasting. However, often during a flood emergency power is out, leaving computers, telephones and/or televisions and radios nonfunctional. During a flood, emergency responders should be prepared to provide warning to the public by other means.

- ✓ Ensure dissemination of flood information between communities and agencies. It is important to note that during the stakeholder input collection phase of this study, a frequently addressed concern was the lack of communication between communities and agencies along the Virgin River and its tributaries. In order for emergency responders to adequately understand the situation, it is necessary for flood information to be passed in both the upstream and downstream direction. To this end, it is recommended that a Virgin River and Tributaries Emergency Action Flow Chart be created, which should provide an algorithm for decision makers to follow.

Flood Response Plan Implementation. Once flood information has been collected, assessed and disseminated, a Flood Response Plan should be executed. It is recommended that the Flood Response Plan be developed as part of the communities' overall Emergency Action Plan (EAP), and should include the following basic information:

- ✓ Purpose of the plan.
- ✓ Legal authority of the plan.
- ✓ Planning factors and assumptions.
- ✓ How the plan works.
- ✓ General flooding issues and high risk areas and infrastructure.
- ✓ Who is in charge during an emergency.
- ✓ Organizational responsibilities and contact information.
- ✓ How the Flood Response Plan relates to the overall EAP.
- ✓ Communication methods to be used between responders and decision makers.
- ✓ Methods for alerting and informing public.
- ✓ Critical incident stress management.
- ✓ Public protection strategies.
- ✓ How Flood Response Plan is tested and updated.
- ✓ Action protocols, which should include a checklist and flow diagram applicable for each level of responder and decision maker.
- ✓ Watercourse maps.

- ✓ Road maps.
- ✓ Distribution list.

Flood response may take several forms, depending on the severity of flooding, and may include one or more of the following actions:

- ✓ Sand bagging in high risk areas to limit extent of flooding and protection of critical infrastructure.
- ✓ Road closures.
- ✓ Installation of temporary pumps or installation of aqua-dams or other temporary flood retarding measure.
- ✓ Moving high-value stocks, supplies and equipment.
- ✓ Clearing of culverts and/or bridge openings to prevent flow blockage.
- ✓ Continued monitoring of flood control infrastructure.
- ✓ Issuance of an Evacuation Alert. An Evacuation Alert should include information such as evacuation routes, where to register if accommodations are required and other tips for a safe and efficient evacuation.

7.2 Strategic Goal B: Improved Floodplain Management

In order to achieve the strategic goal of improved floodplain management, the following mitigation actions have been identified based on data and information collected during the initial phase of this project:

- ✓ **Physical System** – Implementation of proactive, nonstructural methods for flood control, erosion control and water quality protection.

- ✓ **Regulatory System** – Identification, development and application of regulatory tools to be used for floodplain management within the Virgin River watershed.

7.2.1 Physical System

The physical system is comprised of numerous watercourses, which when taken collectively create a complex, interrelated and interdependent riparian and aquatic habitat within the Virgin River watershed. This physical system is defined by the technical data and resources collected and maintained by the floodplain administrators, agency personnel and engineers working within the watershed. Mitigation actions items that can help define, maintain and enhance this physical system include the following:

- ✓ **Mitigation Action 6 – Flood Detection Network.** Installation and maintenance of flood detection networks.

- ✓ **Mitigation Action 7 – Post-Fire Hydrologic Assessment.** Assessment of post-fire impacts on watershed hydrology and channel morphology.

- ✓ **Mitigation Action 8 – Floodplain Delineations.** Delineation of floodplains and floodways.

- ✓ **Mitigation Action 9 – Erosion Hazard Zone Delineations.** Delineation of erosion hazard zones.

- ✓ **Mitigation Action 10 – Channel Conveyance Conservation.** Conservation of flow area within riparian corridor.

7.2.1.1 Mitigation Action 6 – Flood Detection Network

Reliable flood forecasting and early detection of flood conditions are critical components of effective local and regional flood warning programs (ALERT Website, 2007). Automated Local Evaluation in Real Time (ALERT) is a flood detection method that uses remote sensors in the field to transmit collected environmental data (rainfall, flow depth and discharge, wind speed and direction, temperature, etc.) to a central computer. ALERT stations were developed in the 1970's by the National Weather Service and are now commonly used by local, county, state and Federal agencies. Exhibit A-1 shows ALERT station locations throughout the Virgin River watershed. In addition, information regarding each identified ALERT station is provided in table format, located in Appendix C.

Benefits of installing and maintaining an ALERT station network include the following:

- ✓ Low Cost/High Benefits ratio.
- ✓ Real time data acquisition.
- ✓ Automated hydrologic and hydraulic modeling.
- ✓ Automated flood warning.

Accurate, real time flood data can help reduce injuries, prevent death and decrease property damage. For these reasons, it is recommended that communities and agencies operating within the Virgin River watershed establish and maintain a seamless flood detection network. The network should consist of ALERT stations (both weather and stream gage stations) located at strategic locations along the Virgin River and its significant tributaries. Given the importance of sharing real time flood information, data collected by the network should be stored in a central system that is accessible by all. In addition, a redundant secondary system should collect and store network data, which can then be used as a backup to the primary storage system. It is understood that several ALERT stations are currently in use throughout the watershed; these stations can serve as the foundation of the network. It is recommended that all existing and future ALERT stations be integrated into one overall flood detection network that can collect, store and disseminate information to all interested parties throughout the Virgin River watershed.

The loss of a stream gage (due to pressure transducer being lost or damaged) during severe flooding is not an uncommon occurrence. Therefore, it is recommended that

installation of future stream gages include adequate anchoring of pressure transducers. Similarly, existing stream gage stations should be assessed and upgraded if necessary, which will include an evaluation of the pressure transducer anchoring.

Continued successful operation of a flood detection network requires

A listing of ALERT station venders is provided on the following web site: http://www.alertsystems.org/.

7.2.1.2 Mitigation Action 7 – Post-Fire Hydrologic Assessment

For floodplain hazards associated with wildfires, preventative actions are likely to be more effective than emergency actions. This is primarily because flooding from burned areas, as described is Section 5.1, occurs more rapidly and severely than under non-burned conditions. Following wildfires, several avenues may be pursued to address flooding hazards. These actions may be programmatic, administrative, or structural. The following action items pertaining to wild fires and flood and erosion mitigation are recommended:

- ✓ **Risk Awareness**: A central source for fire data within the watershed is not readily available in an easily digested format. Development of a cooperative fire data center specific to the Virgin River watershed is of value. While local needs may be known, the post-fire hazards associated with wild fires may not be apparent to those in proximity to them. A centralized, updated fire data collection for the watershed would facilitate decision-making by a broader audience.

- ✓ **Risk Assessment:** Fire risk assessment relies upon a combination of asset identification, fire risk analysis, and flooding risk analysis. Actions to be taken to assess fire risks include the following:

  - Identify critical assets and infrastructure. This effort may parallel or duplicate other asset identification tasks undertaken for the purpose of flood mitigation, such as development of an ALERT system. This effort may have been completed as part of a pre-disaster mitigation plan.
  - Identify hydrologic contributing areas for critical assets and locations.
  - Identify fire hazards and fire-prone areas within critical contributing areas (see Figure 22).
  - Assess asset vulnerability to flooding by developing rainfall-runoff models, which account for the following:
    - Fire return interval.
    - Burn intensity.
    - Plant succession and regrowth rate.
  - Rank areas of highest risk.

  Results from fire risk assessments should be compared to those from FEMA analyses and regional methodologies such as USGS regional regression estimates

and stream gage data to evaluate the regional applicability of FEMA flood hazard criteria. If a significant percentage of area or number of communities is found to be at an unacceptable risk, flood hazard criteria should reflect this high risk scenario.

Several tools are available for risk assessment within the watershed. These tools include BLM post-fire analyses (Burned Area Emegency Stabilization [BAER] reports), and NPS post-fire reports.

✓ **Risk Response:** Risk response planning entails reducing risk from specific sources based upon an understanding and prioritization of risks identified in a risk assessment. Response actions tend to be location and hazard specific and should include the following:

- Identification of critical aspects of risk for each site.
- Development of risk reduction actions, which may be structural or non-structural (administrative, regulatory, programmatic). Examples include:

  - Flood warning/detection.
  - Emergency Action Plans.
  - Seeding/plantings.
  - Application of surface roughness elements.

It is recommended that an outline of applicable responses to mitigate flooding in areas impacted by wild fires be a standard part of every Emergency Action Plan (EAP).

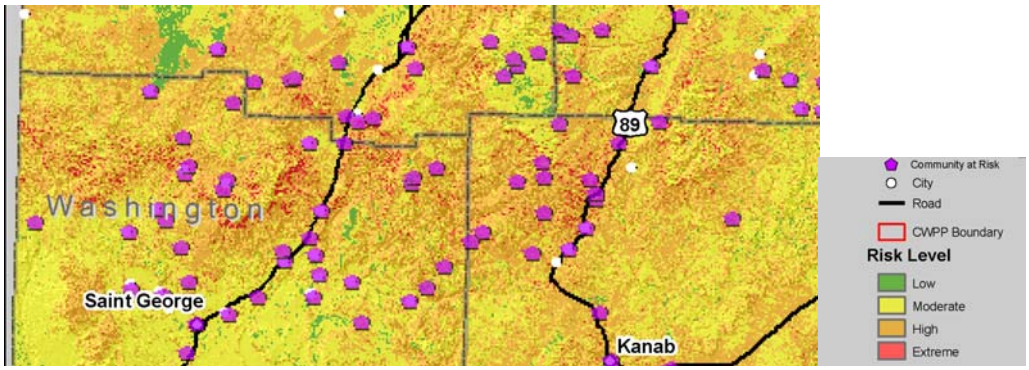


Figure 22 - Wildfire Risk Assessment In Southern Utah
Source: Color Country Fire Risk Assessment using Fuels, Slope, Aspect, and Historical Fire Occurrence (www.utahfireinfo.gov)

7.2.1.3 Mitigation Action 8 - Floodplain Delineations and Mitigation Action 9 – Erosion Hazard Zone Delineations

In order to improve floodplain management within the Virgin River watershed, it is first necessary to identify previously delineated floodplains, as well as the delineation completion date. Floodplains are most commonly delineated under the National Flood

Insurance Program (NFIP), operating under the Federal Emergency Management Agency (FEMA). Typically these NFIP delineations are based on a 100-year storm event. However, this does not preclude local, county or state agencies from identifying additional jurisdictional watercourses, which may or may not be submitted to FEMA. It is recommended that floodplains be delineated for watercourses shown to convey 50 cfs or more during a 100-year storm event. In addition, it is recommended that the time and effort be put forth to prioritize watercourses, or reaches within watercourses, in need of floodplain delineation. Prioritization should provide the basis for delineation selection as funding becomes available. All new floodplain delineations should adhere to FEMA standards as a minimum, which includes the new levee certification process.

Similar to assessment of existing and future floodplain delineations, floodway and erosion hazard zone (EHZ) limits require identification and prioritization. Floodway limits will identify areas of high velocity and deep flow. EHZ limits will identify areas subject to erosion through channel widening, migration, avulsion and/or headcutting/ tailcutting. Prioritizing watercourses, or reaches within watercourses, that require these types delineations should provide the basis for delineation selection as funding becomes available.

It is recommended that all watercourses with a delineated floodplain, floodway and/or EHZ be subject to jurisdictional authority as outlined in local, county, state and/or Federal floodplain regulations and/or ordinances. Watercourses with a delineated floodplain and/or floodway, and which are available in digital format (GIS shape files), are shown on Exhibit D-1. FEMA FIRM panel boundaries and identification numbers are shown in Exhibit E-1; the associated FIRM panel information in tabular format is provided in Appendix B. In addition, various examples of floodplain delineation scopes of work are provided electronically on the DVD, located in Appendix H. Watercourses with a delineated EHZ are shown on Exhibit F-1.

7.2.1.4 Mitigation Action 10 – Conservation of Flow Conveyance Area

Based on the discussions above, it is prudent to ensure that a sufficient flow conveyance area is maintained within the riparian corridor and that a riparian corridor template is established. In order to obtain and/or maintain adequate flow conveyance, the following mitigation actions are recommended in addition to the establishment of the riparian corridor itself:

- ✓ Vegetation Managemen
- ✓ Riparian Corridor Land Acquisition
- ✓ Appropriate Land Use Planning.
- ✓ Installation of Supplemental Bank Protection
- ✓ Identification of Regulatory Floodway
- ✓ Encroachment Prevention
- ✓ Establishment of Riparian Corridor Templates

Vegetation Management. Vegetation management is a cost effective, proactive approach to flood protection, erosion control and water quality protection. This flood mitigation effort entails the removal of excessive vegetation within the riparian corridor in order to maintain the ability of the corridor to adequately function (safely transport water and sediment) in such a way that the risk of flood damage is reduced or eliminated. In addition, vegetation management controls the introduction of invasive, nonnative vegetation to the riparian corridor. Typical vegetation management practices include mowing, discing, hand clearing and/or herbicide applications. For additional discussion regarding tamarisk and cheat grass, two prevalent, invasive vegetation species found within the Virgin River watershed, see Section 5.4.

Riparian Corridor Land Acquisition. Given how the state or health of a riparian corridor may influence flood control, erosion control and water quality protection, the acquisition of land for these corridors is a useful, proactive tool for the Floodplain Administrator. Typically acquisition of a riparian corridor is achieved through local regulations/ordinances and zoning, land purchase and/or the establishment of conservation easements (discussed later in this section). Prior to land acquisition, it is recommended that a riparian corridor template be developed in order to identify flood prone areas, as well as areas subject to erosion (see Figure 23 and Figure 24).

Appropriate Land Use Planning. When development within an established riparian corridor is imminent, it is recommended that it be limited to either an active or passive open space land use. Selection of either active or passive open space is dependent on the proximity to the central channel and the overall riparian corridor template.

- ✓ Acceptable land uses within an active open space area includes parks or agricultural fields. Open spaces are areas that will likely contain sparse infrastructure or buildings, and will often be heavily used by the community or property owner. Because of the relatively frequent activities within this area, as well as the capital costs associated with potential infrastructure, it is suggested that these areas be located on the high terraces within the riparian corridor. This area will be inundated during large events, at which time some level of flood damage should be expected.
- ✓ A passive open space area will contain minimal infrastructure; however, no infrastructure within this area is recommended. Acceptable land use within a passive open space area may include some type of designated trail system. These areas should be located on the low terraces identified within the riparian corridor. This area will be inundated during moderate events, at which time flood damage should be expected.

It is strongly recommended that both active and passive land use areas be located outside the geomorphic floodplain identified within the riparian corridor template. The geomorphic floodplain area should be reserved for natural open space land use, preventing any development within the area. The geomorphic floodplain will experience relatively frequent flooding. Heavy damage to any infrastructure located within this area should be expected.

Installation of Supplemental Bank Protection. In response to the January 2005 flooding that occurred within the Virgin River watershed, the NRCS constructed riprap bank protection along various reaches of the Virgin River, Santa Clara River and Beaver Dam Wash (see Exhibit C-1). As stated in the *Santa Clara River Master Plan* (Natural Channel Design, 2005),

> *"The NRCS dikes were designed and constructed to protect properties from floods equal to the magnitude of the January 2005 floods. While there was considerable property damage from that flood, hydrologic analyses suggest higher flood events can be expected. These floods will overtop the dikes, flooding areas above and behind them. However, the dikes are structurally designed to withstand large flood events and should reduce catastrophic lateral bank erosion."*

Although beneficial, the NRCS dikes are not adequate for protection against a 100-year flood event. In addition, there are areas subject to severe erosion that have yet to be identified or mitigated. It is recommended that adequate time and resources be allocated for the assessment of existing NRCS structures and the need for supplemental bank protection, as well as the identification of areas lacking bank protection.

Identification of Regulatory Floodway. The regulatory floodway is typically the area within the floodplain that contains the deepest and fastest moving water. It is the primary conveyance corridor for both water and sediment. However, it is an area that is not always identified during the floodplain delineation process. Given the volume of water transported within the floodway, as well as the higher flow velocities typically seen within the floodway, obstructions occurring within this area often induce severe flooding and erosion. For this reason, it is recommended that delineation of floodway limits be a mandatory part of all floodplain delineation studies.

Encroachment Prevention. As discussed in Section 5.3, urbanization often results in the encroachment of development into a floodplain, floodway and/or erosion hazard zone without an adequate understanding of the stream's tendency and potential to flood and/or laterally migrate. Typical encroachment scenarios, and the recommended mitigation action to be taken, are listed in Table 4.

Table 4 - Typical Encroachment Scenarios and Associated Recommended Action

Encroachment Scenario	Recommended Action
Development Outside of Regulatory Floodplain, Floodway and Erosion Hazard Zone	Allow development.
Development Inside Regulatory Floodplain, but Outside Floodway and Erosion Hazard Zone	Ensure all finish floor elevations are adequately above the base flood water surface elevation.
Development Inside Erosion Hazard Zone, but Outside of Floodplain and Floodway	Provide structural protection against lateral migration of the channel.
Development Inside Regulatory Floodplain and Erosion Hazard Zone, but Outside of Regulatory Floodway	Ensure all finish floor elevations are adequately above the base flood water surface elevation and provide structural protection against lateral migration of the channel.
Development Inside Regulatory Floodplain, Floodway and Erosion Hazard Zone	Do not allow development.

Establishment of Riparian Corridor Templates. Riparian corridors connect the riparian and aquatic systems throughout the Virgin River watershed. As stated in the *Riparian Setbacks Technical Information for Decision Makers (Chagrin River Watershed Partners, Inc, 2006)*,

> *"Riparian corridors include the stream channel and its adjacent land where vegetation may be influenced by high water tables, flooding or the ability of soils to hold water."*

If properly maintained and sized, these corridors offer a low-cost, proactive approach to floodplain management. Benefits resulting from the adoption of riparian corridors include the following:

1. Flood Control – Flooding is a natural occurrence that maintains the form, function and connectivity of stream channels and floodplains. The establishment of a stable riparian corridor template, and riparian corridor setbacks, ensures sufficient room for this maintenance to take place, without adversely impacting adjacent property. As documented by Dutchess County, New York (Holly, 1991),

   > *"Floodplains function well as emergency drainage systems - for free - when they are left undisturbed. The public pays a high price when misplaced or poorly designed development interferes with this function. Human encroachment on the natural flood corridors often increases the risk to downstream homes and businesses by increasing the volume of runoff and altering the flood path. The resulting demands for costly drainage improvements, flood control projects, flood insurance, and disaster relief are all, ironically, preventable by conserving and respecting the floodplains from the outset."*

2. Erosion Control – Channel erosion may be caused by the erosive force of flowing water within the channel, as well as the erosive effects of surface runoff approaching the channel. Healthy vegetation growth established and maintained within a riparian corridor presents a physical barrier to overland flow, enhancing infiltration and lessening the potential for runoff induced erosion. In addition, root systems hold bank soils in place against the erosive force of high velocity flow, which maintains soil structure and bank stability.

3. Water Quality Protection – Similar to erosion mitigation, healthy vegetation established and maintained within a riparian corridor traps and filters sediments, nutrients and a range of other contaminants that are often associated with urbanization. These contaminants are often generated from diffuse sources and are categorized as nonpoint source pollutants. During development nonpoint source pollutants are mitigated through the establishment of Best Management Practices (BMPs) (see Section 5.3 for additional discussion).

In order for urbanization to occur safely with respect to flood hazards, it is recommended that riparian corridor templates be created to show appropriate width and depth of alluvial features. Templates can be used to help developers identify areas adjacent to rivers, streams and washes that should remain open, as well as provide a blueprint for reconstruction/restoration of disturbed riparian corridors.

As discussed in the *Santa Clara River Master Plan* (Natural Channel Design, 2005), a riparian corridor template should be created based on assessment of a stable, healthy reach located in close proximity to the area of interest. A stable riparian corridor is capable of conveying water and sediment with minimal erosion. The fluvial morphology and hydrology associated with a stable riparian corridor should be used to measure the components that define the corridor template. Components of the riparian corridor template include the following:

- ✓ Channel – The central channel conveys base flow and frequent flood events. It is typically the area containing the deepest and fastest moving water, and therefore transports the greatest volume of sediment through the system. Vegetation in this area is rare, but when present may consist of well-rooted herbaceous plants, wetland species and/or shrubby, woody species. The channel is defined by its cross-section geometry, planform and profile.

- ✓ Geomorphic Floodplain – The geomorphic floodplain is a low feature found adjacent to the channel, and is formed due to relatively frequent overtopping of the channel banks (floodplain inundation usually occurs annually or every couple years). The geomorphic floodplain is typically not coincident with the regulatory, 100-year floodplain and should remain open and clear of all development. Vegetation in this area is sparse and may consist of supple, woody species.

- ✓ Low and High Terraces – Terraces are typically abandoned floodplains, higher in elevation than the geomorphic floodplain. These features are typically formed as

the active channel degrades (erodes vertically over an extended period of time). However, these features may also be formed as the geomorphic floodplain is inundated during very large events, resulting in large alluvial bar deposition.

- Low terraces are likely to be flooded during moderate events and make for a good location of passive open space, such as a trail system. Vegetation on low terraces would consist of supple, shrubby-woody species, as well as willow, ash, cottonwood and box elder tree species.

- High terraces are flooded during large events and are an acceptable location for active open space land uses, such as agriculture and recreation. High terraces are capable of sustaining many varieties of native vegetation and cultivated plants.

Characteristics of a stable, healthy riparian corridor include the following:

- ✓ Elevations within the corridor shall rise away from the central channel.
- ✓ Roughness shall increase away from the central channel. Floodplain and terrace vegetation provides increasing roughness to help ensure high velocities remain in the central channel.
- ✓ Plan form transitions shall be gradual.

Figure 23, Figure 24, Figure 25, and Figure 26, (obtained from the *Santa Clara River Master Plan, Natural Channel Design, 2005)*; depict the riparian corridor template as discussed above.

In addition to the physical characteristics of riparian corridor template, erosion hazard zones that identify the limits of potential channel lateral migration and/or bank erosion should be acknowledged during corridor template development. Lateral migration may take several forms, including channel widening, channel avulsion and/or stream capture. Lateral migration may occur along a reach, or may be a localized phenomenon due to some type of flow blockage within the channel. The loss of property and homes along the Virgin River due to bank erosion during the January 2005 flood illustrates the importance of establishing erosion hazard zones. Additional discussion regarding erosion hazard zones is presented in Section 5.2.1.

Given the benefits that a riparian corridor provides, it is recommended that a riparian corridor be identified for any watercourse conveying a minimum of 50 cfs during the 100-year storm event.

7.2.2 Regulatory System

The regulatory system is comprised of administrative, technical and permitting personnel, whom typically work in some capacity for a local, county, state or Federal agency. These agencies are responsible for the maintenance of floodplain environments within the

Virgin River watershed. Recommended mitigation actions to be taken by regulatory agencies include the following:

- ✓ **Mitigation Action 11 – Ordinances/ Regulations.** Adoption and enforcement of non-structural, proactive floodplain, floodway and erosion hazard zone regulations/ordinances.

- ✓ **Mitigation Action 12 – Design Standards/ Guidelines.** Adoption and utilization of design standards, guidelines and publications.

- ✓ **Mitigation Action 13 – Maintenance.** Improved maintenance of riparian corridor through a more efficient, streamline permitting process.

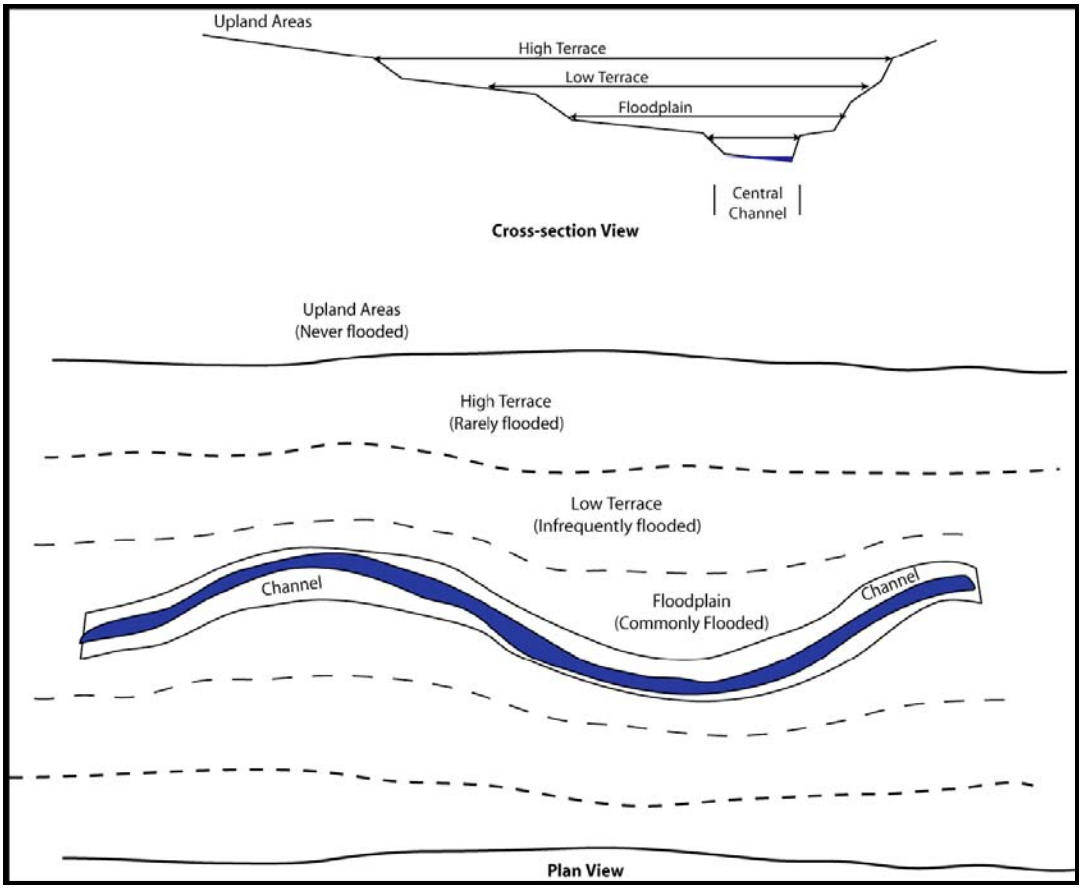


Figure 23 - Riparian Corridor Template
(*Santa Clara River Master Plan*, Figure 2-8)

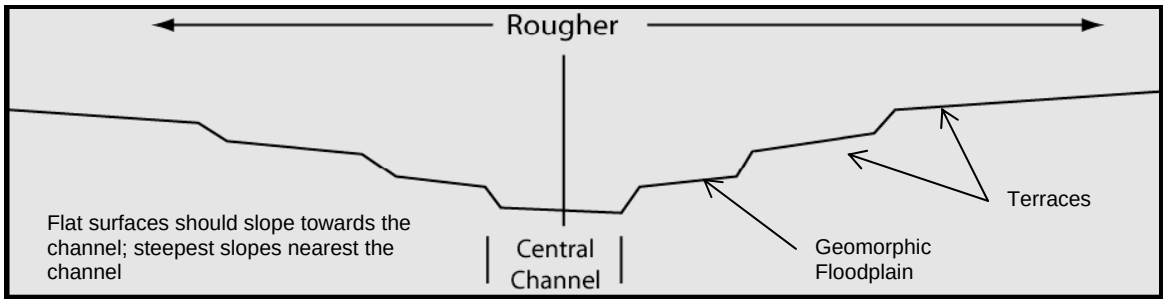


Figure 24 - Riparian Corridor Template Cross-Section
(*Santa Clara River Master Plan*, Figure 3-6)

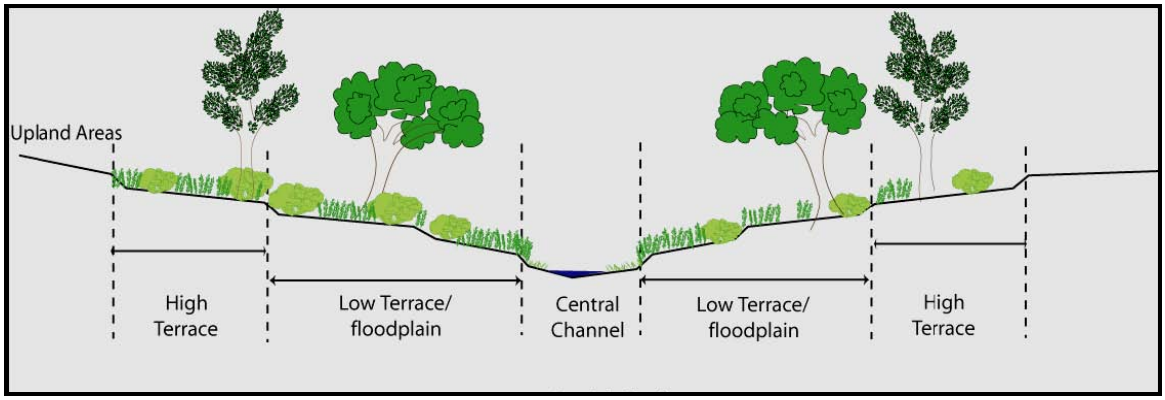


Figure 25 - Appropriate Roughness
(*Santa Clara River Master Plan*, Figure 2-13)

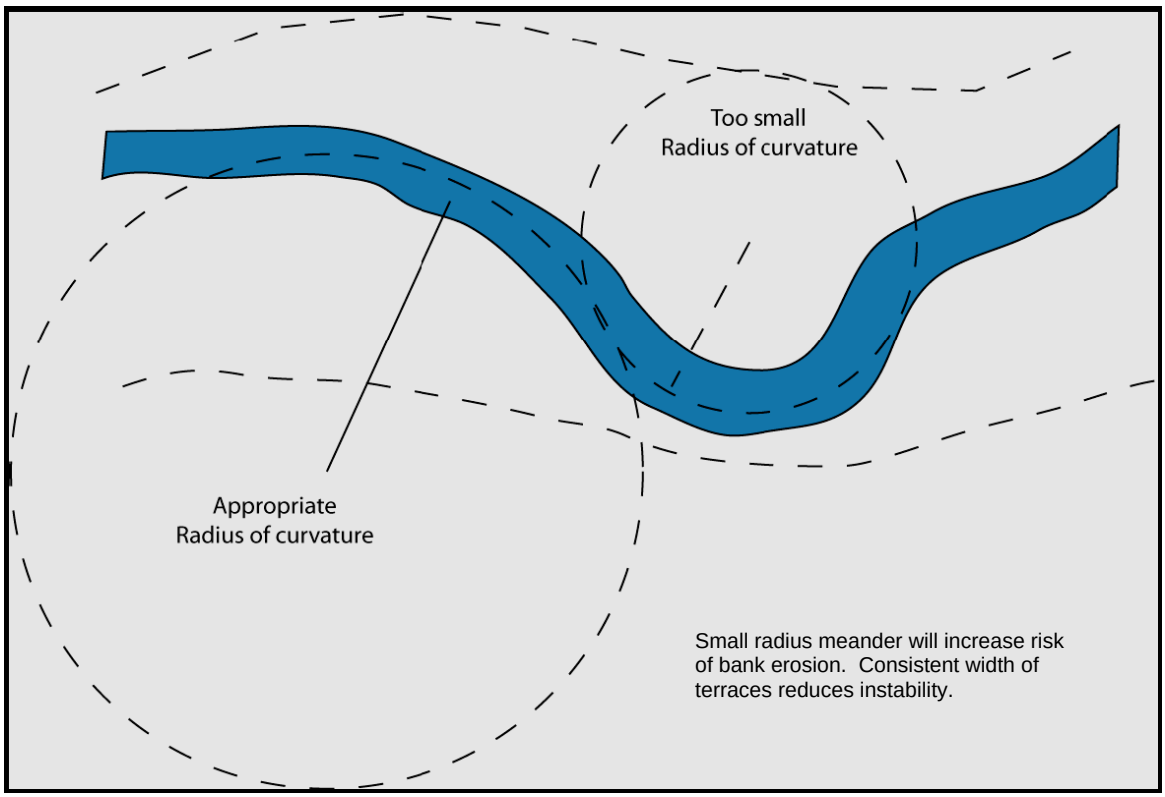


Figure 26 - Recommended Transitions for Riparian Corridor Template
(*Santa Clara River Master Plan*, Figure 3-10)

7.2.2.1 Mitigation Action 11 – Ordinances/ Regulations

As urbanization or development occurs, floodplain, floodway and erosion hazard zone (EHZ) regulations and/or ordinances are useful tools to ensure that river management policies support the preservation of the natural river system, promote land uses that are compatible with a natural river system, and limit improvements inside established regulatory limits (i.e. floodplains, floodways and EHZs). Well developed and implemented floodplain, floodway and EHZ regulations provide the following benefits to a community and its residents:

- ✓ Protection of life, health and property.
- ✓ Minimizes use of public money for flood control projects.
- ✓ Reduces public money spent for restoration efforts after a flood event.
- ✓ Minimizes rescue and relief efforts associated with flooding.
- ✓ Alerts property owners as to whether their property may be located within a flood hazard area.
- ✓ Prevents hazardous encroachment within floodplain areas, as well as minimizes flood damage caused by obstructions located within a floodway.
- ✓ Protects the natural form and function of a watercourse.

The above benefits are actualized when floodplain, floodway and EHZ regulations accomplish the following:

- ✓ Identification of appropriate streams that require regulation.
- ✓ Restricting or prohibiting activities (including construction of homes, businesses and infrastructure) within regulatory waterways that endanger health, safety and property due to flooding or erosion hazards. This includes activities that may increase the potential for flooding or erosion.
- ✓ Control of modifications made to natural floodplains, channels and protective barriers, which help convey flood waters.
- ✓ Restricting or prohibiting the construction of flow obstructions that result in an adverse impact to upstream and downstream properties, which includes the unnatural diversion or splitting of flow.

Current Practice

Local floodplain regulations vary throughout the watershed. Jurisdictionally, regulations may be divided by Federal, state, county, and local jurisdiction.

Federal floodplain regulations are stipulated by the terms of participation in the National Flood Insurance Program (NFIP). The participation terms of the NFIP form the minimum requirements for participation in the program; individual participants may promulgate more restrictive regulations.

Within the watershed, state regulations focus largely on managing multi-county or high hazard resources such as dams. Nevada and Arizona regulations establish loan programs

for local agencies to address flooding hazards. Little interaction with the NFIP is regulated other than authorizing communities to operate and maintain federally constructed flood control projects and indemnifying the federal government against damages which may result from the operation of the structures.

County regulations within the watershed conform to the requirements of the NFIP. All six counties within the Virgin River watershed participate in the NFIP. A summary of selected regulatory topics for several counties in the watershed is included in Table 5.

Local community regulations vary significantly by state and county. Within the watershed, local regulations generally parallel those of their parent county, although some variation is present, particularly within Washington County. Several communities have enacted erosion hazard regulations and are enforcing these regulations through hazard "overlay" zones. An overview of regulatory differences for local governments is presented in Table 5.

Table 5 - Summary of Floodplain Regulations for Selected Topics

Entity	State	Minimum Finished Floor Elevation above BFE (ft)	Erosion Hazard Zone Provisions	"No Adverse Impact" Defined?	Structural Comments
Mohave County	AZ	0	Yes, but either based upon FEMA Zone "E" or "known" areas.	No	
Colorado City	AZ	0	None mentioned	Defined as causing greater than 1 ft rise in BFE	
Clark County	NV	1.5	None mentioned	Defined as causing greater than 1 ft rise in BFE	
Mesquite	NV	1.5	None mentioned	Defined as causing greater than 1 ft rise in BFE	Appears to be based upon Clark County's regulations.
Lincoln County	NV	0	None mentioned	No	Either a floodway must be delineated or a setback of 20' or 5 times the top of bank width of the stream, whichever is greater, is to be applied.

Entity	State	Minimum Finished Floor Elevation above BFE (ft)	Erosion Hazard Zone Provisions	"No Adverse Impact" Defined?	Structural Comments
Washington County	UT	0	No specific mention	Yes, as damage to adjacent properties from inundation due to changes in channel and overbanks.	References are to 100-year floodplain only.
Hurricane	UT	n/a	n/a	n/a	Refers to design standards to be developed by City Engineer and approved by City Council.
Ivins	UT	n/a	Setback/"suitability analysis"	Yes, required to describe impacts in "suitability analysis."	City relies upon "sensitive lands" maps to define hazard areas. Setbacks based upon state, USACE, or zone requirements, whichever is furthest. Washes defined approximately and without flood elevations. Lacks specific guidance, but allows for application of management methods.
LaVerkin	UT	2	None mentioned	No	Similar in structure to Washington County regulations.
Leeds	UT	2	None mentioned	No	Partially based upon City of St. George.

Entity	State	Minimum Finished Floor Elevation above BFE (ft)	Erosion Hazard Zone Provisions	"No Adverse Impact" Defined?	Structural Comments
Santa Clara City	UT	2	Yes, refers to "erosion hazard boundary" maps	No	
Springdale	UT	0	10 ft setback from edge of "overlay zone"	Not explicitly. Activities which worsen flooding are prohibited.	Relies upon floodplain "overlays" which appear to conform to a 1980 study of the Upper Virgin River by Gingery Associates, Inc. Optional public access easements within floodplains are mentioned. Floodplains are reserved as "open space".
St. George	UT	2	Yes, refers to "erosion hazard boundary" maps	Alterations to "watercourses" which cause nuisance or damage to neighboring properties are prohibited.	Specifically requires channel maintenance.
Kanab	UT	n/a	n/a	n/a	No subdivisions are allowed within a floodplain.

Notes:

- Minimum finished floor elevation above BFE applies for floodplains with elevations associated with them and for residential construction. Other types of development and other types of floodplains may be regulated differently.

Recommended Actions

It is recommended that floodplain, floodway and EHZ regulations be applicable for areas located within, and adjacent to, a delineated regulatory floodplain. Therefore, in order for these regulations to be effective, a basis for establishing areas of special flood hazard must be acknowledged. Typically the areas of special flood hazard identified by the National Flood Insurance Program (NFIP), operating under the Federal Emergency Management Agency (FEMA), are accepted under local, state and Federal regulatory jurisdiction. However, the special flood hazard areas identified by the NFIP on a flood insurance rate map (FIRM) only depict areas subject to inundation during a 100-year event (floodplain limits). Within the floodplain limits, a regulatory floodway may be identified. It is important to note that a FIRM does not depict areas of special flood hazard as they relate to an EHZ, which is an area subject to bank erosion, channel lateral migration, channel avulsion, etc.

Special flood hazard areas depicted on a FIRM are typically the minimum area subject to regulatory action; the terms of participation in the NFIP stipulate regulation requirements within FIRM-defined floodplains. However, it is recommended that regulatory floodplains, floodways and EHZs be delineated for watercourses that convey flows equal to or greater than 50 cfs during a 100-year event. In addition, jurisdictional authorities should use supplemental studies to delineate, or require developers of land to delineate, special flood hazard areas (including areas subject to erosion) where development is ongoing or imminent. Regulatory agencies should also reserve the right to designate special flood hazard areas when it has been determined through a study, watercourse master plan or other flood related study that a hazard exists due to high-velocity flows, erosion, sediment transport, deposition, unstable soil conditions or land subsidence.

No Adverse Impact

The concept of “no adverse impact” (NAI) represents a more stringent floodplain management standard than required by the participation terms of the NFIP. As a participant in the NFIP, a regulatory body may allow activity within the floodplain that creates up to a 1-foot rise in the water surface elevation, assuming a floodway is defined. The NFIP-definitions of the floodway and floodway-fringe (floodplain) do not account for any potential impacts to upstream and downstream properties. In short, while floodplain encroachment is allowable under the minimal NFIP requirements, it may adversely impact other property owners and increase flood-related damage to the adversely impacted properties. While NAI is not required to participate in the federal flood insurance program, it is recommended by the national Association of State Floodplain Managers (ASFPM).

Table 5 shows NAI definitions, if available for select municipal and county entities within the watershed. Substantial disparity is present in what is considered a “permissible” alteration to floodplain elevations.

Development Permits

Construction plans and associated drainage reports/studies should be submitted to a Floodplain Administrator for review. Decisions regarding these plans should be made in accordance with all floodplain, floodway and EHZ regulations. If development is to occur within the limits of a floodplain, floodway, or EHZ, the following minimum regulations should hold applicable:

1. All development within a regulatory floodplain or floodway shall meet the National Flood Insurance Program requirements, or meet more stringent requirements that have been adopted by local, state or Federal regulatory agencies.
2. Floodplain, floodway and erosion hazard zone boundaries shall not be revised unless a study sealed by a registered professional engineer is performed.
3. A Floodplain Use Permit, issued by a Floodplain Administrator, shall be obtained prior to beginning any proposed addition, alteration or change of any building, structure, land or other use within a regulatory delineated floodplain, floodway or EHZ.
4. An Elevation/Floodproofing Certificate shall be prepared by a registered engineer or land surveyor and shall be required prior to occupancy or use of any building within a regulatory floodplain.
5. Homes, businesses and infrastructure shall be constructed to preserve an adopted riparian corridor template (see Section 7.2.1.4) and should not increase the 100-year base flood elevation.
6. Development within an adopted EHZ shall adhere to the following regulations:
    a. Development within the adopted EHZ shall occur only if protected by adequately designed erosion protection and upon approval from the Floodplain Administrator.
    b. Within an adopted EHZ the following land uses may exist upon approval from the Floodplain Administrator:
        i. Agriculture.
        ii. Recreation areas (parks, golf courses, etc).
        iii. Open space.
    c. Fences shall be designed to break away during flood events. Fences shall not divert flow from its ordinary course, by obstruction of flood water or by catching debris.
7. Development adjacent to NRCS structures shall adhere to the following regulations:
    a. Development within NRCS structures:
        i. No habitable structures may be constructed between NCRS levees.
        ii. If approved by the Floodplain Administrator, allowable uses include agriculture, recreation/pedestrian areas and open space.
    b. Development above NRCS structures:
        i. If approved by the Floodplain Administrator, allowable land uses include:

- Agriculture.
- Recreation areas.
- Structures - Any development behind a NRCS dike will be at flood and/or erosion risk from large flow events and should be appropriately sited and protected by the following:
    - A minimum 50-foot horizontal setback from the levee top shall be required for all structures.
    - A minimum setback necessary to achieve a 3:1 slope between the top of the levee and structure grade shall be required. Adequately engineered protection from erosion shall be approved prior to construction.
    - Grading and revegetation shall conform to adopted riparian corridor template cross-section.

8. Recontouring and revegetation of special flood hazard areas disturbed by construction or maintenance shall be required.
9. Below grade infrastructure shall be buried below the scour elevation at the riparian corridor invert for the entire corridor width, and shall be protected from lateral erosion for any areas beyond the corridor width.

Identified floodplain, floodway and EHZ regulations and ordinances applicable to the Virgin River watershed are provided in Appendix D.

7.2.2.2 Mitigation Action 12 – Design Standards/ Guidelines

Numerous floodplain management design standards, guidelines and publications are available for Floodplain Administrators, engineers, land planers and regulators to utilize during the decision making process. When reviewing these documents, the following issues should be considered (Arizona Department of Transportation, 1996):

- ✓ The need for safe and effective flood control, erosion control and water quality protection.
- ✓ Planning, design and construction based on realistic financial estimates. This includes a cost-benefit analysis for potential mitigation of adverse impacts to public and private property, natural resources, environmental values, aesthetic values and community goals.
- ✓ The cost, ease and safety of maintaining infrastructure and facilities used to provide flood control, erosion control and water quality protection.

A listing of design standards, guidelines and publications, which are available at no cost and address the above issues, is provided below (State of Nevada Division of Water Resources, 2007).

- ***Hydrological Criteria and Drainage Design Manual***, Clark County Regional Flood Control District, Revised May 2006
- ***Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials***, FEMA 116, February 1987
- ***Design Guidelines for Flood Damage Reduction***, FEMA 15, December 1981
- ***Floodplain Management and Duties of the Local Administrator***, NDWR
- ***Addressing Your Communities' Flood Problems, A Guide For Elected Officials***, Association of State Floodplain Managers and Federal Interagency Floodplain Management Task Force, 1996
- ***Getting Started, Building Support for Mitigation Planning, State and Local Mitigation Planning How-To Guide***, FEMA 386-1, September 2002
- ***St. George City Standard Specifications***, City of St.George, UT, June 2000
- ***State Standard for Development of Individual Residential Lots Within Floodprone Areas (SSA 6-96)***, Arizona Department of Water Resources, June 1996
- ***Above the Flood: Elevating Your Floodprone House***, FEMA 347, May 2000
- ***Adoption of Flood Insurance Rate Maps by Participating Communities***, FEMA 495, September 2005
- ***Alluvial Fans: Hazards and Management***, FEMA-165, May 1989
- ***Answers to Questions About the National Flood Insurance Program***, FEMA
- ***Appeals, Revisions, and Amendments to National Flood Insurance Program Maps, A Guide For Community Officials***, FIA-12, December 1993
- ***Bringing the Plan to Life, Implementing the Hazard Mitigation Plan, State and Local Mitigation Planning How-To Guide***, FEMA 386-4, August 2003
- ***Building a Disaster Resistant Community, Project Impact***, FEMA
- ***Developing the Mitigation Plan, Identifying Mitigation Actions and Implementation Strategies, State and Local Mitigation Planning How-To Guide***, FEMA 386-3, April 2003
- ***Elevated Residential Structures***, FEMA 54, March 1984
- ***Floodproofing Non-Residential Structures***, FEMA 102, May 1986
- ***Guidance on Estimating Substantial Damage Using the NFIP Residential Substantial Damage Estimator, Guidance: Software and Manual Computation Worksheet, Software Version 1.1***, FEMA 311, December 1998
- ***Guidelines for Determining Flood Hazards on Alluvial Fans***, FEMA, February 23, 2000
- ***Homeowner's Guide to Retrofitting, Six Ways to Protect Your House From Flooding***, FEMA 312, June 1998
- ***Integrating Manmade Hazards Into Mitigation Planning, State and Local Mitigation Planning How-To Guide***, FEMA 386-7, Version 2.0, September 2003
- ***Joining the National Flood Insurance Program***, FEMA 496, May 2005
- ***Managing Floodplain Development in Approximate Zone A Areas, A Guide for Obtaining and Developing Base (100-Year)Flood Elevations***, FEMA 265, July 1995, with Quick-2, Version 1.0, Computation of Water Surface Elevations in Open Channels

- ***Manufactured Home Installation in Flood Hazard Areas***, FEMA 85, September 1985
- ***Model Floodplain Management Ordinance for Nevada Communities***, NDWR, December 1999
- ***No Adverse Impact, A Toolkit For Common Sense Floodplain Management***, Association of State Floodplain Managers, 2003
- ***Protecting Building Utilities From Flood Damage***, FEMA 348, November 1999
- ***Protecting Your Home From Flood Damage, Mitigation Ideas For Reducing Flood Loss***, FEMA
- ***Protecting Floodplain Resources, A Guidebook for Communities***, Federal Interagency Floodplain Management Task Force
- ***Reducing Flood Losses Through the International Codes®, Meeting the Requirements of the National Flood Insurance Program***, 2nd Edition, 2005
- ***Subdivision Design in Flood Hazard Areas***, Planning Advisory Service Report Number 473
- ***Title 44 Code of Federal Regulation, Parts 59-78***, National Flood Insurance (NFIP) Regulations, Revised October 21, 2002

Additional Guidelines

- ***Arizona State Standards,*** Arizona Department of Water Resources
  - ***SS1-97 Requirement for Flood Study Technical Documentation***
  - ***SS2-96 Requirement for Riverine Floodplain And Floodway Delineation***
  - ***SS3-94 Standard for Supercritical Flow***
  - ***SS4-95 Standard for Development Within Sheet Flow Areas***
  - ***SS5-96 Standard for Watercourse System Sediment Balance***
  - ***SS7-98 Standard for Watercourse Bank Stabilization***
  - ***SS8-99 Standard for Stormwater Detention/Retention***
  - ***SS9-02 State Standard for Floodplain Hydraulic Modeling***
- ***Draft Erosion Hazard Zone Delineation and Development Guidelines***, Flood Control District of Maricopa County; June 19, 2003
- ***Maricopa County Consultant Guidelines***, Third Edition, Revision 1; December 1, 2003
- ***Maricopa County Drainage Policies and Standards,*** January 11, 2007
- ***Guidelines and Specifications for Flood Hazard Mapping Partners,*** FEMA, April 2003
- ***Flood Proofing Regulations,*** USACE/NFPC, 1995.

In addition to the above listed publications, the *Santa Clara Master Plan* and *Santa Clara and Virgin Rivers River Stability Study* (JE Fuller, 2005) reports have been prepared for the Washington County Water Conservation District. As part of the work completed for these reports, design standards and guidelines are recommended as they pertain to improvements within the riparian corridor (see Section 7.2.1.4).

7.2.2.3 Mitigation Action 13 – Maintenance

In order to adequately maintain the riparian corridor, some degree of permitting is typically required. In addition, permits may often need to be obtained from more than one regulatory agency. Based on gathered input from stakeholders, it is collectively agreed upon that a more efficient, streamlined permitting process would improve the ongoing maintenance procedures required to ensure a stable, healthy riparian corridor.

A number of maintenance tasks are frequently required within a riparian corridor, including vegetation management, bank protection repair, removal of sediment from low flow channels and/or maintaining adequate culvert capacity. Potential permits required to complete any one of these tasks include a Section 404 Permit (Clean Water Act regulated by USACE/EPA), Utah Stream Alteration Permit and/or a local/county Floodplain Use Permit.

USACE Regulatory Program administers the 404 permitting process. Within the watershed, two USACE regulatory districts exist. The Sacramento District is responsible for permitting in Utah and Nevada and the Los Angeles District is responsible for permitting in Arizona; a graphical depiction of USACE boundaries may be found in Appendix A. For certain routine activities performed in Waters of the United States, USACE has developed Nationwide Permits which streamline the 404 permitting process, provided all the terms of the nationwide permit are met. The following nationwide permits, among others, may be applicable for maintenance activities within the watershed.

Table 6 - Selected USACE Nationwide Permits
(Source: http://www.spk.usace.army.mil//organizations/cespk-co/regulatory/nwp.html)

NWP-03 Maintenance
Authorizes activities related to: 1.) the repair, rehabilitation, or replacement of any previously authorized structure; 2.) discharges of dredged or fill material, including excavation, to remove accumulated sediments in the vicinity of existing structures or the placement of riprap to protect the structure; 3.) discharges of dredged or fill material, including excavation, associated with the restoration of upland areas damaged by storm, flood, or other event, including the construction, placement, or installation of upland protection structures.
NWP 37 Emergency Watershed Protection
Authorizes work done by or funded by: a.) The NRCS which is a situation requiring immediate action under its emergency Watershed Protection Program (7 CFR part 624); or b.) The USFS under its Burned-Area Emergency Rehabilitation Handbook (FSH 509.13); or c.) The DOI for wildland fire management burned area emergency stabilization and rehabilitation (DOI Manual Part 620, Ch. 3).
NWP 45 Uplands Repair
Authorizes discharges of dredged or fill material, including dredging or excavation, into all waters of the United States for activities associated with the restoration of upland areas damaged by storms, floods, or other discrete events. This NWP authorizes bank stabilization to protect the restored uplands. The restoration of the damaged areas, including any bank stabilization, must not exceed the contours, or ordinary high water mark, that existed before the damage occurred. The district engineer retains the right to determine the extent of the pre-existing conditions and the extent of any restoration work authorized by this NWP. The work must commence, or be under contract to commence, within two years of the date of damage, unless this condition is waived in writing by the district engineer. This NWP cannot be used to reclaim lands lost to normal erosion processes over an extended period.

The 404 permit process varies depending upon the nationwide permit which is sought; however, the following general process is followed.

- The jurisdictional limits of the "Waters of the United States" are determined for the project by a qualified professional or USACE staff. If determined by a qualified professional, USACE staff may need to approve the determination. This is referred to as a Jurisdiction Determination or Delineation (JD).
- If necessary under the terms of the nationwide permit, the JD is submitted to the appropriate USACE regulatory office for review. Contact should be made with the regulatory office prior to submittal.
- Depending upon the permit requirements and the amount of disturbance to jurisdictional areas, a Pre-Construction Notification (PCN) may be required.
- If a PCN is required, the PCN is submitted to the appropriate USACE regulatory office for review.
- If a PCN is required, the activity may commence once the PCN has been approved by USACE.

In addition to the individual terms of each nationwide permit, regional conditions also apply. These conditions are specific to the USACE regulatory district jurisdiction and the state in which the activity is to occur. Additional requirements and limitations may be

applicable to ephemeral watercourses per the *Rapanos* guidance issued by USACE. As of the writing of this document, this guidance is in the public comment phase.

All terms and conditions of the nationwide permit must be satisfied for the permit to be issued and approved by USACE. Otherwise, an individual permit must be obtained from USACE. Individual permits are highly variable and explicitly require communication with USACE to develop the terms of the permit.

In order to provide a more efficient, streamlined permitting process, the following actions are recommended:

- ✓ Issuance (or reissuance) of Regional General Permits (RGPs) intended to authorize floodplain management actions that have been permitted by a lower-level regulatory agency. RGPs streamline the application and permitting process for projects that require multiple permits from various agencies. Two RGP examples (provided by the USACE) are provided below.

    - **RGP 40:** The District Engineer, Sacramento District, U.S. Army Corps of Engineers (Corps), reissued Regional General Permit 40 (RGP 40) for the discharge of dredged and fill material in waters of the United States (waters) in the state of Utah in those cases where a stream alteration permit has been issued by the State Engineer in compliance with state law (USACE, 2002).

    - **RGP 59:** The U.S. Army Corps of Engineers, Sacramento District, (Corps) issuance of Regional General permit 59 (RGP) under the authority of Section 10 of the Rivers and Harbors Act of 1899, Section 404 of the Clean Water Act (CWA) and for water quality certification or waiver under Section 401 of the CWA for the discharge of dredged and fill material and excavation activities in waters of the U.S. associated with flood protection and flood recovery projects within the State of Utah (USACE, 2005). Although this RGP is expired, it may warrant revisitation.
    - **RGP 60:** The U.S. Army Corps of Engineers, Sacramento District authorizes discharges of dredged or fill material and/or work or structures within the boundaries of the Sacramento District Regulatory Branch (parts of California and Nevada) in waters of the United States, including wetlands, for necessary repair and protection measures associated with an emergency situation. An "emergency situation" is where there is a clear, sudden, unexpected, and imminent threat to life or property demanding immediate action to prevent or mitigate loss of, or damage to, life, health, property or essential public services (i.e., a situation that could potentially result in an unacceptable hazard to life or a significant loss of property if corrective action requiring a permit is not undertaken immediately).

- ✓ Automatic permit renewal for floodplain management activities that occur on an annual basis. Examples of these activities include vegetation and low-flow channel maintenance.

- ✓ Cooperation and communication between local, county, state and Federal agencies to ensure floodplain management activities are not bound by jurisdictional limits. For example, Figure 17 and Figure 18 show a scenario in which multi-jurisdictional permitting would be required for clearing of tamarisk within a reach of the Virgin River that extends from Arizona and into Nevada, just upstream from Mesquite, Nevada.

Consequences of Non-Compliance

When a project is undertaken in a regulated area without a permit, or when a project does not comply with permit terms and conditions, enforcement action may be taken. When a violation is confirmed, USACE seeks to resolve the case in various ways, depending on the circumstances. USACE attempts to contact violators to request information on the activity and to inform them of the violations. A warning letter is usually sent to a violator if the work has already been completed. If the work is ongoing, a cease and desist order is sent to the violator, directing that the unauthorized work be stopped immediately.

If a permitted project is not in compliance with the terms and conditions of the permit, USACE may require a modification of the project to comply with the permit. Alternatively, the permit may be modified to allow for minor deviations from original permit specifications if the impacts are not significant. However, permit modifications are used infrequently for resolving violations.

If a project involves an unauthorized fill in wetlands or other waters, the violator may choose to immediately remove the fill material and restore the site. The case may then be closed, provided the violator did not commit a willful violation of Clean Water Act regulations. If immediate restoration cannot be obtained, USACE notifies other agencies of the violation and requests site-specific comments from them. The Environmental Protection Agency, the U.S. Fish and Wildlife Service, and if appropriate, the National Marine Fisheries Service are notified.

After considering agency comments and information provided by the violator, USACE determines whether the unauthorized activity may be authorized by an after-the-fact permit or whether restoration of the site will be required. Some form of mitigation may be required as well. **In less that 10 percent of cases, the violator is allowed to apply for an after-the-fact permit.** Usually, restoration is required; **more than two-thirds** of violations are resolved by some form of restoration.

The EPA has independent enforcement authority for violations involving fill in wetlands and other waters under the Clean Water Act. Accordingly, some cases are referred to EPA for enforcement action. This occurs in less than ten percent of enforcement cases.

8.0 IMPLEMENTATION PLAN

The VRFPMS is broad in scope and thus will require a focused and collaborative effort among stakeholders for effective and efficient implementation of the various mitigation actions. Specifically, the following elements comprise the Implementation Plan for the VRFPMS:

- ✓ **What** – Mitigation Actions
- ✓ **Why** – Interest/ Benefit to Floodplain Management Goals
- ✓ **How** – Funding and Assistance Programs/ Resource Materials
- ✓ **When** – Short-, Mid-, Long-term Priorities/ Progress Milestone Identification
- ✓ **Who** – Participating Stakeholders/ Partner Resource Agencies

Table 7 presents an overview of the Implementation Plan for the VRFPMS. It is not the intent of this study to fully describe a detailed step-by-step Implementation Plan, but rather to provide a framework within which the decisions are made about how to best approach each of the recommended Mitigation Actions. It is envisioned that the recommended VRFPMS Steering Committee (Section 7.1.1.5 Mitigation Action 14) will provide a forum for collaborative decisions about the logical sequencing of individual steps necessary to implement the floodplain management strategy based on critical need, funding availability, consensus-based support, and other factors. The Steering Committee should also periodically review progress made toward achieving goals and make recommendations for revisions and updates to strategy.

The following priority actions were identified by stakeholders at the December 13, 2007 meeting in Hurricane, UT: Establish a Watershed Steering Committee, Conduct Post-Fire Hydrologic Assessments, Develop and Conduct Public Information/Outreach, and Implement a Flood Warning System (Flood Response Plan/Flood Detection Network).

Table 7 - VRFPMS Implementation Plan

What - Mitigation Action	Why – Goal/ Benefit	How – Potential Funding Mechanism	When – Prioritization/ Timeline	Who – Potential Partners
Mitigation Action 1 **Handbook**	Communication – Non-Emergency/ Information Resources	FEMA Pre-Disaster Mitigation Grant Program Local Jurisdiction operating budget	Short-term priority/ FY 2009	Local Jurisdiction NFIP-participating communities FEMA
Mitigation Action 2 **Public Information Brochure**	Communication – Non-Emergency Information Resources	USACE Flood Plain Management Services (Section 206) Local Jurisdiction operating budget	Short-term priority/ FY 2009	Local Jurisdiction NFIP-participating communities USACE
Mitigation Action 3 **Contacts Database**	Communication – Non-Emergency & Emergency/ Information Resources	Provided in Appendix E Updates by Local Jurisdiction operating budget	Baseline database completed/ Annual updates each FY	VRFMS Steering Committee
Mitigation Action 4 **Flood Response Plan**	Communication – Emergency/ Flood Warning System	USACE Small Flood Damage Reduction Projects (Section 205) FEMA Pre-Disaster Mitigation Grant Program	Priority depends on specific area Short- to Mid-term priority	Local Jurisdictions State FEMA USACE
Mitigation Action 5 **GIS Database**	Communication & Management Non-Emergency & Emergency/ Information Resources	USACE Research & Development?	Baseline database under construction Periodic updates each FY	Initially USACE R&D Long-term host & maintenance?
Mitigation Action 6 **Flood Detection Network**	Management – Physical System/ Basic Data/ Flood Warning System	USACE Small Flood Damage Reduction Projects (Section 205) FEMA Pre-Disaster Mitigation Grant Program	Priority depends on specific area Short- to Mid-term priority Maintenance?	Local Jurisdictions State FEMA USACE
Mitigation Action 7 **Post-Fire Hydrologic Assessment**	Management – Physical System/ Basic Data	USACE Flood Plain Management Services (Section 206) BLM? USGS?	Mid-term priority First need hydrologic model or measured observations	Local Jurisdictions State BLM FEMA
Mitigation Action 8 **Floodplain Delineations**	Management – Physical System/ Technical Resources	FEMA Map Modernization Management Support Program USACE Flood Plain Management Services (Section 206) Local Jurisdiction operating budget	Priority depends on specific area First need mapping	Local Jurisdiction NFIP-participating communities FEMA USACE
Mitigation Action 9 **Erosion Hazard Delineations**	Management – Physical System/ Technical Resources	USACE Flood Plain Management Services (Section 206) Local Jurisdiction operating budget	Priority depends on specific area First need mapping	Local Jurisdiction NFIP-participating communities USACE
Mitigation Action 10 **Channel Conveyance Conservation**	Management – Physical & Regulatory System Channel Conveyance	Local Jurisdiction operating budget	Priority depends on specific area Short- to Mid-term priority Maintenance?	Local Jurisdiction
Mitigation Action 11 **Ordinance/ Regulations**	Management – Regulatory System/ Regulatory Toolbox	Local Jurisdiction operating budget	Short-term priority	Local Jurisdiction
Mitigation Action 12 **Design Standards/ Guidelines**	Management – Regulatory System/ Regulatory Toolbox	Local Jurisdiction operating budget	Short-term priority	Local Jurisdiction
Mitigation Action 13 **Maintenance**	Management – Regulatory System/ Regulatory Toolbox	Local Jurisdiction operating budget	Short-term priority	Local Jurisdiction
Mitigation Action 14 **Virgin River Floodplain Management Steering Committee**	Communication & Management/ Non-Emergency & Emergency/ Information Resources		On-going	USACE BLM

8.1 Funding and Assistance Programs

Multiple funding and technical resources are presented below. These sources have specific requirements with respect to matching funds, project scoping and type, and application protocol which have been excluded for the sake of brevity. Additional information for each funding program is provided via accompanying URLs. This list is not intended to be exhaustive or inclusive, but is meant to present broadly-available assistance sources.

An excellent tool for finding funding and technical resources for water resources applications is available through Boise State University's Environmental Finance Center. Their directory of watershed resources can be found at:
http://efc.boisestate.edu/watershed/

8.1.1 Federal Assistance

8.1.1.1 Funding

The **FEMA Pre-Disaster Mitigation Grant Program** provides funding for hazard mitigation planning and implementation prior to a disaster event. The program has specific restrictions on use of funds including the following ineligible project activities: major flood control projects; warning and alert notification systems; phased or partial projects; studies that do not result in a project; flood studies or mapping; projects that solely address a manmade hazard; response and communication equipment; projects that solely address maintenance or repairs of existing structures, facilities, or infrastructure; and any project for which another federal agency has primary authority. For more information, visit http://www.fema.gov/government/grant/pdm/index.shtm

The **FEMA Hazard Mitigation Grant Program** (HMGP) provides grants to States and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. The HMGP is authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. For more information, visit http://www.fema.gov/government/grant/hmgp/

Examples of projects include, but are not limited to:

- ✓ Acquisition of real property for willing sellers and demolition or relocation of buildings to convert the property to open space use
- ✓ Retrofitting structures and facilities to minimize damages from high winds, earthquake, flood, wildfire, or other natural hazards
- ✓ Elevation of flood prone structures
- ✓ Development and initial implementation of vegetative management programs

- ✓ Minor flood control projects that do not duplicate the flood prevention activities of other Federal agencies
- ✓ Localized flood control projects, such as certain ring levees and floodwall systems, that are designed specifically to protect critical facilities
- ✓ Post-disaster building code related activities that support building code officials during the reconstruction process

The **FEMA Repetitive Flood Claims Program** provides funding to assist states and communities to reduce flood damages to insured properties that have had more than one claim to the NFIP. The primary role of this program is the acquisition of insured properties subjected to repeated flood damage. To be eligible, subject properties must be deed restricted for open space into perpetuity. For more information, visit http://www.fema.gov/government/grant/rfc/index.shtm

The **FEMA Map Modernization Management Support (MMMS) Program** provides grants to assist ongoing flood hazard mapping management efforts by local, regional, and state agencies. Program eligibility is limited to communities participating in and in good standing with the NFIP. Specific requirements of the program are the creation of a data collection and delivery system including a geo-spatial system which supports risk management applications and provides reliable flood hazard data. For more information, visit
http://12.46.245.173/pls/portal30/CATALOG.PROGRAM_TEXT_RPT.SHOW?p_arg_names=prog_nbr&p_arg_values=97.070

The **FEMA Flood Mitigation Assistance** program bears a number of similarities to the FEMA Repetitive Flood Claims Program and the FEMA Pre-Disaster Mitigation Grant Program. The program provides funds to purchase or remove NFIP-participating properties from floodplains. Additionally, the program provides funding for planning activities which do not match the following ineligible activity types: flood studies or flood mapping; risk assessments, technical assistance, information dissemination or workshops not resulting in a FEMA-approved Flood Mitigation Plan; ground disturbing activities; and non-flood planning activities. For more information, FEMA has developed a program guidance document which is available at
http://www.fema.gov/library/file?type=originalAccessibleFormatFile&file=fy2007_fma_guidance.txt&fileid=136080a0-6f06-11db-8645-000bdba87d5b

The **USACE Small Flood Damage Reduction Projects (CAP Section 205 of 1948 Flood Control Act (PL 80-858)) Program** provides funding for the construction or improvement of structural features such as levees, channels, and dams to reduce flood damage. Non-structural methods such as flood warning systems, elevating structures, and relocating structures subject to flood damage are also considered. Additional information and statistics are available at
http://cfpub2.epa.gov/fedfund/program.cfm?prog_num=108

The **USACE Section 14 "Emergency Streambank and Shoreline Protection (Section 14 of the 1946 Flood Control Act)** funds the design and construction of emergency

streambank protection for protection of public facilities which include water/sewer lines, churches, public and private nonprofit schools and hospitals, and other nonprofit public facilities. Additional information on this program can be found at http://www.nww.usace.army.mil/html/pub/ap/facts/sec14.pdf

The **EPA Targeted Watershed Grants Program** provides funding for "collaborative watershed partnerships that are ready to implement on-the-ground restoration and protection activities design to achieve quick, measurable environmental results." Additional information on this program can be found at http://www.epa.gov/owow/watershed/initiative/

8.1.1.2 Technical

The **NRCS Conservation Technical Assistance Program** provides NRCS technical resources to "reduce soil loss from erosion; …reduce potential damage caused by excess water and sedimentation or drought;…and assist others in facilitating changes in land use as needed for natural resource protection and sustainability." Assistance is available to a variety of entities both public and private. Additional information is available at http://www.nrcs.usda.gov/programs/cta/

The **NRCS Emergency Watershed Protection Program** provides post-event rehabilitation and protection assistance. Typical program activities include debris removal from waterways, vegetation restoration, and bank stabilization. This program was applied in Washington County and Mohave County following the 2005 flood. Triggering of this program is contingent upon an official federal state of disaster declaration. Additional information is available at http://www.nrcs.usda.gov/programs/ewp/

The **USACE Flood Plain Management Services Program** (Section 206 of the 1960 Flood Control Act (PL 86-645)) provides the full range of technical services and planning guidance that is needed to support effective flood plain management. Technical services include the development or interpretation of site-specific data on obstructions to flow, flood formation and timing, flood depths or stages, flood water velocities, and the extent, duration and frequency of flooding. On a larger scale, the program provides assistance and guidance in the form of "Special Studies" on all aspects of floodplain management planning. Some of the most common types of Special Studies include:

- ✓ Floodplain Delineation/ Flood Hazard Evaluation Studies
- ✓ Dam Break Analysis Studies
- ✓ Flood Warning/ Preparedness Studies
- ✓ Regulatory Floodway Studies
- ✓ Comprehensive Floodplain Management Studies
- ✓ Flood Damage Reduction Studies
- ✓ Urbanization Impact Studies
- ✓ Stormwater Management Studies
- ✓ Floodproofing Studies
- ✓ Inventory of Floodprone Structures

- ✓ Preparation of Guides and Pamphlets

Additional information is available at
http://www.saw.usace.army.mil/Floodplain/FPMS.htm

The **USACE Flood Fighting Assistance Program** provides technical assistance for local governments to aid in "flood fighting." Activities associated with this assistance include technical advice, direct contracting assistance, and supplies. Similar to the NRCS Emergency Watershed Protection Program, a state of emergency or written request from a state governor is necessary to trigger this program. Additional information is available at http://www.spd.usace.army.mil/floodf.html

The **USACE Planning Assistance to States Program** (Section 22 of the 1974 Water Resources Development Act) provide the Corps authority to assist states, local governments, and other non-federal entities, in the preparation of comprehensive plans for the development and conservation of water and related land resources. The program can encompass many types of studies dealing with water resources issues. Types of studies conducted under the program include the following:

- ✓ Water Supply and Demand Studies
- ✓ Water Quality Studies
- ✓ Environmental Conservation/Restoration Studies
- ✓ Dam Safety/Failure Studies
- ✓ Flood Damage Reduction Studies
- ✓ Floodplain Management Studies

Additional information is available at:
http://www.spd.usace.army.mil/cwpm/public/plan/pdguide/guide.htm

The **NRCS Watershed Protection and Flood Prevention Act** is implemented through three programs by the NRCS: Watershed Surveys and Planning, Watershed Protection and Flood Prevention Operations, and Watershed Rehabilitation. Traditionally, these programs have been implemented as joint studies between the NRCS and other state, federal, and local agencies. More information on these programs is available at
http://www.nrcs.usda.gov/programs/watershed/

8.1.2 State

No significant state-originated funding opportunities exist in Nevada or Utah for the purposes outlined in this study. Additional state funding may be available at a project-specific level, but does not appear to be generally or programmatically provided.

In Arizona, the **Arizona Water Protection Fund** provides funding for "projects that will enhance riparian areas." Grant applications are available at
http://www.awpf.state.az.us/pubs/FY2008/FY%202008%20Grant%20Application%20Manual.pdf

8.1.3 County/Municipal

The Virgin River watershed is located within six counties: Washington, Kane, and Iron Counties in Utah, Clark and Lincoln Counties in Nevada, and Mohave County in Arizona. No specific programmatic funding is available for floodplain or watershed management for the Virgin River Watershed from these counties. Again, individual project funding may be available through local operating budgets, but no perennially funded grant programs exist.

8.2 Data Sources

A variety of geospatial data is available for portions of the Virgin River watershed. As part of this project, select data has been organized and compiled for inclusion in a GIS-format data package and in the resource materials provided in Appendix H. While some data has been collected, additional data is available on a variety of scales. What follows is a summary of data collected with this project and readily available data with sources.

8.2.1 Included Project Data

A variety of datasets have been collected and compiled to aid in watershed planning. A brief listing of datasets and sources follows. Due to the nature of this project, these datasets should not be assumed to be comprehensive as other agencies may provide additional or modified data. A full listing of data used for the project is available in Appendix F and selected shapefiles are available in Appendix H.

FEMA and county-recognized floodplains have been included for the entire watershed. This data is current as of the development of this report, but should not be relied upon as a final floodplain determination tool for property owners.

Erosion hazard zones for Washington County have been included. EHZs have been defined along portions of the Santa Clara and Virgin Rivers as well as Beaver Dam and Sand Hollow Washes.

Wildland fire data from 1994-2006 has been found and compiled from a variety of sources including two BLM field offices, one BLM state office, and a USGS study of fires in the Western United States from the SAGEMAP project (http://sagemap.wr.usgs.gov). The BLM data covers the entire watershed, but the years of coverage varied by source. Although the SAGEMAP data was designed to be comprehensive for its years of coverage (through 2003), burn areas were included in the BLM data prior to 2003 that were not contained in the SAGEMAP data.

8.2.2 Other Available Data and Sources

The NRCS maintains the Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/GatewayHome.html) which allows users to select by state, county, or bounding polygon an area to check the availability of US Department of Agriculture geospatial data. While all datasets are not available in every area, the following datasets are generally available: NRCS soil surveys, general soil surveys,

countywide digital raster graphics (DRGs, scans of 1:24,000 USGS topographic maps which have been trimmed and mosaiced to provide continuous coverage for a county), digital ortho-quads (1-meter pixel black-and-white aerial imagery which has been mosaiced on a county-wide basis), average precipitation data, average temperature data, 1:24,000 watershed boundary datasets (watershed boundaries digitized from 1:24,000 USGS topographic maps), USGS quadrangle indexes for a variety of map scales, National Elevation Dataset (NED) products at 10 and 30-meter pixel resolutions, and NRCS National Agricultural Imagery products for 2003, 2004, 2005, and 2006 where available. All data is publicly available and delivered free of charge provided the datasets are below a threshold of 4096 megabytes.

In Utah, a wide variety of data is available from the Utah Automated Geographic Reference Center (http://agrc.utah.gov). Specific datasets listed are too numerous to mentioned, however data of the following general types are available: aerial imagery, political boundaries, zip codes, property ownership, hydrographic information, utility information, habitat data, geologic data, and others.

Nevada BLM data is available at http://www.nv.blm.gov/gis/geospatial_data.htm.

9.0 COMMUNICATION PLAN

A well coordinated, multi-faceted communication plan is an essential component to any floodplain management strategy. The challenges associated with implementing such a plan within the Virgin River watershed include the following:

- ✓ The overall watershed is approximately 5,900 square miles in size and encompasses numerous towns, cities and counties, as well as the States of Utah, Arizona and Nevada.
- ✓ The watershed is multi-jurisdictional, which includes local, regional, county, state and Federal regulating agencies.
- ✓ Funding for implementing a complete communication strategy would likely be shared between jurisdictional entities; however, often the entities in most need of a well established communication plan have the least available funding.
- ✓ There has been a historic lack of communication between jurisdictional entities in regards to floodplain management and flood hazard warning.

In order to overcome the above communication plan challenges, the following information resources are recommended:

1. Development and publication of the *Floodplain Management Handbook* (Mitigation Action 1). The intent of the *Handbook* should be to provide both the technical and non-technical communities a tool for making educated, practical decisions in regards to flood control, erosion control and water quality protection. The *Handbook* will also serve to provide information continuity in cases of personnel turnovers. Previous discussion regarding the *Handbook* is provided in Section 7.1.1.1.

2. Development and publication of Public Information Brochure (Mitigation Action 2). The Brochure should educate the general public about flood and erosion control measures, as well as water quality issues. Previous discussion regarding the Brochure is provided in Section 7.1.1.2.

3. Publication and maintenance of the Contact Database provided in Appendix E (Mitigation Action 3). As discussed in Section 7.1.1.3, in order to achieve the strategic goal of improved communication, mitigation actions associated with both emergency and non-emergency scenarios need to be addressed. In addition, it is essential that both intra- and inter-communication take place within and between local, county, state and Federal agencies. To that end, a communication database (see Appendix E) has been developed for use as a basic floodplain management tool.

4. A communication flowchart is a key work product of the Flood Response Plan (Mitigation Action 4). The flowchart is intended to clearly present communication links, means, protocols, and redundancies for use in emergency situations. A recommendation for successful implementation of the Flood

Response Plan is to conduct regular training exercises which test the communication protocols and their robustness. See Sections 5.5 and 6.5 for previous discussion of the Flood Response Plan.

5. Development and maintenance of a GIS database (Mitigation Action 5). The database should contain the following:

   - ✓ Spatial information resource
   - ✓ Aerial photos
   - ✓ Applicable shapefiles (i.e. FEMA floodplains, erosion control measures, subwatersheds, etc.)
   - ✓ Links to information resources (i.e. *Floodplain Management Handbook* and Public Brochure, Contact Database, Design Standards, etc.)
   - ✓ Links to work products (i.e. Virgin River Watershed Analysis Report, Virgin River Floodplain Management Strategy Report and other studies/reports)

6. Creation of a Virgin River Floodplain Management Strategy Steering Committee (Mitigation Action 14). The Oversight Group would include local, county, state and Federal representatives that have a vested interest in a successful watershed management strategy. Various members of the Steering Committee would be selected to form a Technical Committee responsible for the review and endorsement of reports, studies, design standards/ guidelines, and floodplain ordinances/ regulations that pertain to the Virgin River watershed. The Steering Committee would be responsible for dissemination of both technical and non-technical information to the jurisdictional entities within the watershed, as well as providing a forum for ongoing dialogue between floodplain managers.

10.0 NEEDS ANALYSIS FOR FUTURE ACTIVITIES

One outcome of the Corps' Virgin River Watershed Analysis is a needs analysis that is intended to assist in summarizing floodplain issues, identify existing efforts throughout the watershed, and prioritizing areas of unmet needs. A needs analysis helps to determine mitigation actions necessary to address identified needs in the formulation of the strategy. Focus areas include the major issues identified within the watershed: floodplain management, invasive species, land use planning, threatened & endangered species, and water supply.

With specific regard to the VRFPMS, stakeholders provided input through individual and workshop discussions about goals and actions for floodplain management. General needs and actions identified early formulation of the floodplain management strategy include the following:

- ✓ *Maintenance* – There is a need for better consideration and planning for maintenance of structures and projects. (i.e., sedimentation, bank stabilization, tamarisk, etc.).

- ✓ *Regulatory Permits* – There is a need for a streamlined process to obtain permits for maintenance activities in the channels.

- ✓ *Floodplain Delineations* – Prioritize floodplain delineations away from major watercourses and include detailed studies where needed.

- ✓ *Erosion Hazard Delineations* – Prioritize watercourse reaches in need of erosions hazard assessment and delineation.

- ✓ *Mitigation Action Prioritization* – There is a need to prioritize mitigation actions and assess the associated risks (i.e., tamarisk and maintenance activities).

- ✓ *Communication* – Multi-level communication needs improvement and funding is required for that purpose. A handbook with information about flood risks for decision makers, realtors, and lenders would be a beneficial tool to enhance communication. An information brochure addressing flood risk and floodplain management for the general public is needed.

- ✓ *Model Ordinances* – Model ordinances are needed in several areas.

- ✓ *Flood Warning System* – There is a need for more ALERT precipitation and stream gages to expand the flood detection network throughout the watershed. Flood response plans are needed along with the expanded gage network to best utilize those data for effective flood warning purposes.

- ✓ *Contact Database* – Contact information needs to be shared in form of a book or database.

In addition, each stakeholder agency in attendance at the August 2007 workshop was requested to provide their input regarding prioritization of needs for their agency. A summary of the information discussed is provided below:

- ✓ *Santa Clara City, Utah* – Technical needs are currently mostly addressed. Needed are: permitting for maintenance, early flood warning, flood response plans, handbook for continuing education of decision makers, funding or assistance in finding it, project priorities, and risks and deficiencies if no action is taken. A steering committee or district or other form of governing body for the purpose of oversight of the implementation of the floodplain management strategy is needed, similar to the wildfire committee.

- ✓ *St George City, Utah* – Flood response plan and disaster response plan could be improved. An ALERT system for flood detection is also needed. A general mailing to the public with a professional-looking brochure could help to inform the public about more specific potential problems in their local community.

- ✓ *Gunlock, Utah* – Given the recent experiences of the August 2007 Santa Clara River flood event, ALERT gages and an organized flood response plan are needed.

- ✓ *Washington County Water Conservancy District, Utah* – Tamarisk toolbox, permitting needs, early flood warning, communication plan, evaluation of the flood potential on Fort Pearce and Beaver Dam washes are needed.

- ✓ *Washington County, Utah* – Update to current emergency response plans is needed. Additional gages or spotters are needed on the Santa Clara River above Vail or Brookside, and below Gunlock Dam for early warning. Formal guidelines on managing volunteers during emergency events would be useful.

- ✓ *Mohave County, Arizona* – Floodplain regulations and ordinances, expanded floodplain mapping of washes are needed. Mohave County is evaluating an ALERT system for Beaver Dam Wash.

- ✓ *Clark County, Nevada* – Additional gages upstream in the watershed to provide better advance flood warning and longer response times.

- ✓ *Utah Department of Water Resources* – Additional gages are partially funded by UDWR, but cutbacks are occurring. If the need for gages is shown, that may assist in maintaining funding.

The needs and concerns expressed by stakeholders were foundational to the development of the floodplain management goals and the identification of mitigation actions required to attain those goals. The next step in the implementation of the VRFPMS is to identify and prioritize specific projects for each of the Mitigation Actions and to secure funding for those projects in accordance with the Implementation Plan. The materials contained in the Mitigation Action toolbox provided in Appendix H are intended for use a resource materials for assistance in progressing to next steps in the implementation of the VRFPMS. Similarly, Table 2 lists previous Virgin River watershed flooding and floodplain management reports. These contain useful context for determining next steps in implementing the recommended Mitigation Actions.

11.0 RECOMMENDATIONS

The following priority actions were identified by stakeholders at the December 13, 2007 meeting in Hurricane, UT: Establish a Watershed Steering Committee, Conduct Post-Fire Hydrologic Assessments, Develop and Conduct Public Information/Outreach, and Implement a Flood Warning System (Flood Response Plan/Flood Detection Network).

Additionally, to establish and maintain a successful floodplain management strategy within the Virgin River watershed, the following measures are recommended:

1. **Distribution, Maintenance and Update of the *Virgin River and Tributaries Floodplain Management Strategy Report.***
   The *Virgin River and Tributaries Floodplain Management Strategy Report* should be distributed to primary stakeholders. All remaining floodplain managers, administrators and emergency management personnel within the watershed should be made aware that an electronic version (pdf format) of the *Floodplain Management Strategy Report* is available via the U.S. Army Corps of Engineers. In addition, the *Floodplain Management Strategy Report* should be kept up-to-date through ongoing maintenance and updating.

2. **Improved Communication (Strategic Goal A, Section 7.1)**
   As discussed in Section 7.1, effective communication is a key element of successful floodplain management. To help facilitate better communication between both technical and non-technical floodplain managers and administrators, the following tools are provided within the *Floodplain Management Strategy Report*:

   - Communication database listing identified floodplain managers and administrators (Appendices E and H, Mitigation Action 3).
   - Outline for development of a *Floodplain Management Handbook* to be used by both technical and non-technical floodplain managers and administrators (Appendix H, Mitigation Action 1).
   - Example brochures (Appendix H, Mitigation Action 2) for communicating flood hazards and flood response plan to the general public.

3. **Improved Floodplain Management (Strategic Goal B, Section 7.2)**
   The *Floodplain Management Strategy Report* provides floodplain managers with the necessary tools and implementation plan for improving floodplain management strategies. The tools include each of the fourteen Mitigation Actions discussed throughout the *Floodplain Management Strategy Report*. In addition, the Implementation Plan outlined in Section 8.0 provides floodplain managers and emergency management personnel with the following information:

   - *Why* implementation of Mitigation Actions is important.

- *Who* should implement Mitigation Actions.
- A *timeframe* for implementation of Mitigation Actions.
- A *means* for implementation of Mitigation Actions (funding sources for financial support of, and data sources as information resources for, execution of Mitigation Actions).

4. **Synchronization with Overall Virgin River Watershed Analysis**
   The *Floodplain Management Strategy Report* is one part of the overall Virgin River Watershed Analysis being completed by the USACE. Given that a healthy riparian habitat is dependent on the overall heath of the watershed, it is vital that all components of the overall Virgin River Watershed Analysis be compatible.

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